INTEGRATION OF COMPUTERS WITHIN THE ARCHITECTURAL DESIGN PROCESS AND DESIGN EDUCATION STUDIOS

By

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In the Name of ALLAH
Most Gracious, Most Merciful

To my parents, my sister, Samira, and my wife, Nafa,

with love and appreciation

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by

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The purpose of this study was to identify the potential uses of computers within the architectural design process, to identify curriculum needs for integrating computers within architectural design education studios, and to develop a proposal for integrating computers within the architectural design process and curriculum.

The study was conducted in three phases. The first phase took the form of a Nominal Group Technique (NGT) which involved a panel of 10 members of the University of Florida's Architecture faculty; in two meetings the panel produced two lists, one identifying potential uses of computers, the other outlining possible curriculum needs.

Phase two involved the distribution of questionnaires to architectural professionals. The questionnaires summarized the NGT findings and sought reactions from architectural educators and

practitioners in 100 schools, members of the Association of Collegiate Schools of Architecture, and 150 randomly selected firms. The 105 respondents were assigned to one of four groups based on their profession and their use or non-use of computers: educators/users, educators/non-users, practitioners/users, and practitioners/non-users.

Four null hypotheses pertaining to difference among the variables of architectural profession and work setting were postulated for this study. They were tested using a one-way analysis of variance and a two-way analysis of variance. In this analysis, the educators' and practitioners' perception served as the dependent variable. The profession factor (educators and practitioners) and setting factor (users and non-users) served as the independent variables. Significant differences were found at the .05 level for three of the four hypotheses. Although educators and users perceived computers to have more potential in the design process than practitioners and non-users, observed means support a consensus among the four groups on specific potential uses of computers and curriculum needs. Further analysis of the overall calculated F-ratios indicated that the factor of using or not using computers had the greater impact on both architectural educators' and practitioners' perception of the computer's potential.

In the third phase, a designer/computer interactive model within the architectural design process and an architectural design/computer integrative curriculum proposal were developed.

CHAPTER I
INTRODUCTION

Over the last 20 years there has been an extensive amount of writing devoted to the use of computers in the architectural design process. Most efforts have been aimed at determining the stages in the design process and specific design functions in which computers may be effectively utilized. The task, however, is not easy, for as most researchers have learned, "assimilating a universal set of typical design procedures to which the computer might be applied, was made difficult by the diversity of individual design methodologies found in architectural practice" (Pata, 1988, p. i).

Although there are some questions concerning the impact computers might have on the quality of the architectural design process, researchers have agreed that the use of computers in architectural design is an inevitability. Gero (1977) concluded from his research of the use of computers in architecture that

> the computer is a general purpose tool which cannot be ignored. . . . The use of computers in architecture is no longer in its infancy but neither has it reached maturity. Any architect who fails to examine the applicability of computers to do his work is failing himself. (pp. 1,11)

The issue, how to utilize computers in design practice in architectural offices, has created a gap in the relationship between practitioners and educators. Practitioners want architectural schools to provide new graduates with expanded skills, graduates who are trained in the use of computers both for efficiency in the office and for assistance in the design process. They complain that changes are not taking place in academic settings. The computer as a design aid remains an underutilized resource as a result. In this one aspect, recent graduates from architectural schools are unable to meet the needs of the profession (Filson, 1985, Greenfield, 1972, Lazear, 1984).

This situation has generated interest in the educational world. For instance, a study by the Department of Architecture, Carnegie-Mellon University (Akin, Fleming, & Woodbury, n.d.), stated that, although theory exists regarding the incorporation of the computer fruitfully into the design process, in practice

> computers are primarily used as a means to increase productivity by making the execution of routine tasks more efficient. Computer technology has had little impact on the way in which designs are created, which continues to follow the traditional intuitive approach. Computers have not been used in education in a way that fosters intellectual development of alternate approaches to design. (p. 1)

Purpose of the Study

The purpose of this study was to identify the potential uses of computers within the architectural design process, to identify curriculum needs for integrating computers within architectural design education studies, and to develop a proposal for

integrating computers within the architectural design process and curriculum.

Part I of the investigation was designed to answer the following questions:

1. What are the potential uses of computers within the architectural design process?

2. What are the curriculum needs that would allow the integration of computers within architectural design education studies?

The following research questions were examined in Part II of this study:

1. Are there differences between architectural educators who are working in computerized settings and architectural educators who are working in non-computerized settings in their perception of curriculum needs that would allow the integration of computers within architectural design education studies?

2. Are there differences between architectural educators' and architectural practitioners' perception of the potential uses of computers within the architectural design process?

3. Are there differences between architectural educators and practitioners who are working in computerized settings and architectural educators and practitioners who are working in non-computerized settings in their perception of the potential uses of computers within the architectural design process?

The long-term objective of this research was to assist decision-makers in both architectural education and the computer industry. For the architectural educators, this research will help provide answers to the question of how to integrate computers in the architectural curriculum, considering the rapid changes in computer technology. For the computer industry, research results

will provide guidance in the development of software for use in architectural education and practice.

Hypotheses

In Part II of this study the following null hypotheses were tested at an alpha level of .05:

1. There is no significant difference between two categories of architectural educators in their perception of curriculum needs that would allow the integration of computers within architectural design education studies.
2. There is no significant difference between architectural educators and architectural practitioners in their perception of the potential uses of computers within the architectural design process.
3. There is no significant difference between two categories of architectural educators and practitioners in their perception of the potential uses of computers within the architectural design process.
4. There is no significant interaction between the setting levels and the profession levels categorized in hypothesis three.

Research Plan

This study consisted of three phases. Phase I was conducted in the form of a Nominal Group Technique (NGT). A group of 15 faculty members from the Department of Architecture, University of Florida, were selected to participate in the NGT panel. Through the NGT process, the potential uses of computers within the architectural design process and the curriculum needs for the integration of computers within architectural design education studies were identified.

In Phase II, the findings of the NGT process were distributed to a random sample of 150 architectural firms and to the 100 architecture schools which were members of the Association of Collegiate Schools of Architecture (ACSA). A comparison of the educators' perceptions and evaluations of these findings with those of practitioners served as the base for the final recommendations.

In Phase III, the findings of the analyses conducted in Phase II, the NGT process, and the literature review served as the base for the development of a designer/computer interactive model and an architectural design/computer integrative curriculum proposal.

Significance of the Study

Architectural design procedures have been slow to change with respect to incorporating state-of-the-art computer technology. Architects who advocate the use of computers believe that the computer offers virtually untapped potential for enhancing the architectural design process from inception through completion. Although computers appear to have significant advantages to offer architects, universities have been slow to adopt the computer as a tool in the architectural design process. Educational planners find themselves faced with the dual problem of integrating the computer into existing programs and providing for the rapid changes in computer technology which affect the future of the profession.

Among architects, interest in computer-aided design fostered the formation in 1981 of the Association for Computer-Aided Design in Architecture (ACADIA). ACADIA sponsors an annual workshop, with a focus on computer applications to architecture. The 1985 and 1988 workshop programs demonstrated the extent to which professionals, educators as well as practitioners, are concerned with this issue (ACADIA, 1985, 1988). Conversations with ACADIA personnel revealed to this researcher how eagerly the profession awaits data which will facilitate the use of the computer as an effective aid in design.

However, Wendle (1983) pointed out some cautions about computers. He questioned the pervading belief that computers plus architecture equals successful practice:

> A computer system is an excellent tool that can contribute to your thought and decision process, but be careful that its very presence does not limit your ability to think and respond creatively . . . Certainly future architectural practice will embrace computer technology, and the applications for the hardware and software will be imaginative and far reaching. Despite their capabilities, however, computers are only a complement to, not a substitute for, good management . . . and sound professional judgment. (p. 78)

In an early report, Haviland (1968) cautioned those who are involved to be careful not to fall into what he called the trap of "seeking applications: The question, how can the computer be applied to architecture is misguided, dangerous, and foolish; . . . The best way to avoid it is to keep in mind the symbiosis of man and machine. Where are extra advantages to be gained from the combination?" (p. 8).

The debate continues in print about the use of computers in the architectural profession. The question of how and where computers could be best utilized to enhance human creativity within the design process has not been answered. This research was designed to provide information to help answer the question: How can the computer, as a design aid, be integrated effectively into the architectural design education studio?

Delimitations

This study was aimed at the use of computers as an aid in the design process. Only the published research and the expert opinions relating to this aspect were reviewed. Also, the computer was viewed as a tool for use by architects, the study did not include an examination of possible technology, either hardware or software.

The procedure used in this study was to apply the Nominal Group Technique (NGT) to assess the usage of computers in the architectural design process only. Therefore, other components of the use of computers in the architectural profession and in developing the technology were not studied.

The 100 architectural schools involved in this study were preselected by virtue of their membership in the Association of Collegiate Schools of Architecture (ACSA). The predetermined size of the schools' sample and the desirability of selecting an architectural firms' sample comparable in size meant that the population of the firms should be limited. Therefore, the 150 firms which participated in this study were randomly selected from

the southeastern and northeastern regions of the United States. This limitation of the overall population helped increase the probability of selecting a representative cross-section of firms, that is, both large and small, computerized and non-computerized.

Limitations

This research involved the judgments and opinions of architectural educators and practitioners who are familiar with computers. The conclusions generated may lack the technical points of view of the computer science experts.

Due to the geographical limitation on the firms' sample, the perceptions of responding practitioners and the conclusions generated may reflect regional bias.

Definitions

Nominal Group Technique (NGT) is a structured group meeting which follows a prescribed sequence of problem-solving steps. The nominal group meeting proceeds along the following format: generation, discussion, and mathematical evaluation of ideas. (Delbecq, Van de Ven, & Gustafson, 1975).

Architectural design process as used in this study is a sequence of stages that lead to the solution of architectural design problems. Through this process "a problem is defined verbally, then solved graphically through a reiterative and cyclical process, ultimately leading to a physical form that has meaning for the designer, client, and user" (Pate, 1986, p. 8).

Computerized settings are the architectural schools and professional firms that use computers in the design process.

Non-computerized settings are the architectural schools and professional firms that do not use computers in the design process.

Curriculum needs are in reference to potential changes or adjustments that may be necessary in order to make optimum use of computers in the design process.

Architectural educators' and practitioners perception as used in the null hypotheses of this study is defined as the perception and/or philosophy of the schools and firms with which these individuals are associated.

The specific design function refers to any of these design functions identified through the Nominal Group Technique (NGT) process where computers have potential.

The specific curriculum change refers to any of those curriculum changes identified through the Nominal Group Technique (NGT) process that would allow the integration of computers within architectural design education studios.

The two categories of architectural educators as used in null hypothesis I of this study are

1. Those architectural educators who work in computerized settings and have already implemented the specific curriculum change to allow the integration of computers within architectural design education studios.
2. Those architectural educators who work in non-computerized settings and have not made the specific curriculum change to

allow the integration of computers within architectural design education studios.

The two categories of architectural educators and architectural practitioners as used in null Hypotheses 2 and 3 of this study are

1. Those architectural educators and architectural practitioners (professional levels) who are using computers in the architectural design process (computerized setting).
2. Those architectural educators and architectural practitioners who are not using computers in the architectural design process (non-computerized setting).

Technical process (T) refers to those design functions (tasks) in which the process of finding an answer is formalized (rational process).

Non-technical process (NT) refers to those design functions (tasks) in which the process of finding an answer is not formalized (intuitive process).

CHAPTER II
LITERATURE REVIEW

Literature concerning computer-aided design systems in relationship to the design process in architecture is discussed in this chapter. Also reviewed here are studies that examined the relationship between architectural education and professional practice in regard to cooperative planning for educating future architects. Finally, literature related to the Nominal Group Technique (NGT) is discussed.

Computer-Aided Architectural Design

Computer-aided architectural design (CAAD) is an information processing system used in the development of alternative solutions to a particular architectural problem. It is intended to aid the architectural designer in reaching solutions in these problems. In addition, a CAAD system is expected to help the architectural designer in the creation of two-dimensional and three-dimensional drawings that are normally required in his/her typical architectural practice (Mitchell, 1977a).

Fate (1985) defined a CAAD system as an information processing system that

1. stores and retrieves all information gathered by the architectural designer and related consultants,

7. helps define architectural design problems in the form of design goals,

8. identifies all the possible alternative solutions that satisfy the conditions of the defined design goals. (p. 31)

The development of CAAD systems began as a natural growth from the computer-aided design (CAD) systems which were originally developed for the engineering profession (Mitchell, 1977a; Pate, 1986). Today, most of the CAAD systems are still indicative of this engineering background. This resulted in the production of what is basically an automatic drafting machine, with no real ability to address the architectural design process. Of the three CAAD functions defined above, "only the first ones of data storage and retrieval may apply to many CAAD systems, with the ability to automatically generate alternative design solutions virtually non-existent" (Pate, 1986, p. 33).

Architectural Design and CAAD Systems

In architectural practice, the design process is generally described as having three stages: program development, schematic design, and design development. These stages are in no way considered a linear process. Rather, each stage is composed of a varying number of parts depending on the designer's individual methodology in practice. Synder and Catanese (1979), after examining various views of the design process, divided the three broad stages described above into five basic steps: initiation, preparation, proposal making, evaluation, and action. Additional

typical variations in conceptualization of the design process are presented in Table 1.

In searching for an architectural design model, Goldschmidt (1983) believed that the architectural design process takes place somewhere between "creativeness" and "problem solving," and that architecture, as a profession, must count on a large database of information "with rules pertaining to its teaching, implementation, and perpetuation" (p. 9).

Rowe (1982) defined the use of "heuristic reasoning" as the architects' special capacity which enables them to execute their design tasks insightfully. He viewed design as a "phenomenon where information about a problem is generated, evaluated together with a priori knowledge, and solution strategies assembled together" (p. 18).

Ledewitz (1985), in her writing on the model of design in studio teaching, stated that "there are those, on the one hand, who see design as mysterious artistic inspiration--'non-problem solving'--and, on the other hand, those who see design as a far more complex intellectual activity-- meta-problem-solving'" (p. 3). Ledewitz identified the "analysis-synthesis" model as the one widely used in studio teaching. This process was divided into two discrete and identifiable parts: the analysis phase, in which investigation of site, program, etc., is carried out; and the "pre-design" phase where analytic sketches, diagrams, and reports are produced. At some point, a shift occurs, the design moves from analytic exercises to design proposals. During the proposal stage, "references are made 'back' to analysis work, but no new analysis

Table [illegible] Various Views of the Design Process

Five-step design process	R. Whitaker's eight-step design process	H. Gillis's summary of design process	J. C. Jones's design method	AIA basic and supplementary services	Gunther and [illegible] "Systematic Approach to Architectural Design"
Initiation/ imbalance	Recognition Definition	Identify the problem	Idea		Basic definition Preliminary program
Preparation	Preparation Analysis	Collect information Analyze information	Information Analysis	Predesign services	Investigation, analysis Program abstraction
Proposal making	Synthesis	Create a design Work out details	Synthesis	Schematic design Design development	Synthesis and development Volumetric design proposal
Evaluation	Evaluation	Test solution	Evaluation		Reassessment and modification
Action	Execution Reevaluation	Communicate and implement	Optimization	Contract documents Bidding Administration of contract Postdesign services	

Note: From Introduction to Architecture (pp. 160-161) edited by J. C. Snyder and A. J. Catanese, 1979, New York: McGraw-Hill. Copyright 1979 by McGraw-Hill. Reprinted by permission.

Student design process: Thornley #1	Student design process: Thornley #2	G. T. Moore's design process	M. Asimow: engineering design process	RIBA Architectural outline
	Program formulation	Problem identification		Inception
Accumulation of data	Investigation Assessment of design possibilities	Analysis of user needs Programming	Feasibility	Feasibility
Isolation of general concept or form Development of form	Creation Refinement and presentation	Design synthesis	Preliminary design Detailed design Planning	Outline proposals Schematic design Detail design
		Selection from alternatives		
Presentation of solution		Implementation Postoccupancy evaluation		Production information Bills of quantity Tender action Project Planning Operation on site Completion Feedback

assignments are made. This continues to reinforce the separation of synthesis activities from analysis activities" (p. 4).

Ledewitz cited many critics who considered the analysis-synthesis method of design as a "confusing and inaccurate picture of what designers actually do" (p. 4). Furthermore, "the segregation of analysis from synthesis denies the validity of any preconceptions in design" (p. 4). "The impact of design precedents, typologies, and other knowledge we carry with us is not only inescapable but essential to creative problem solving" (p. 4).

Ledewitz suggested the "concept-test" model as an alternative to the "analysis-synthesis" model. In this method, the "designer conceives of a 'solution in principle' early in the design process, which is progressively developed and refined or discarded" (p. 5).

New methodologies are being sought that would allow the design data, employed during the design process, to be managed as a complete database system. Investigators seek a new methodology which would enhance creativity, by enabling the designer to spend more time on exploring alternative solutions, and less time on physical information management (Jones, 1976; Krauss, 1973).

Krauss (1973), in his writing on the meaning of data in the design process, stated that "guidelines for information frameworks . . . should be open-ended rather than 'complete'; allow the designer to consider any relationship he is interested in; grow with the designer's understanding rather than structure his problem" (p. 343).

Furthermore, Krauss provided four guidelines for the design of information systems that may help designers:

> First, . . . any set of concepts . . . should stimulate modifications, extensions, encourage additions in any direction that the designer's evolving understanding directs . . . .
>
> A second requirement for information systems, is that they cover a wide range of issues . . . in particular they must make accessible the desires and viewpoints of potential users. . . .
>
> Third, information systems should also allow the architect to consider at will any possible connection and inter-relationship among elements . . . [and] enhance his ability to focus on the design as a whole rather than as an aggregation of parts.
>
> Fourth, information systems must be such that they engage the designer's creative intelligence actively rather than appearing to solve his problems for him, they must ensure that the learning process remains his rather than being guided by the dimensions and capabilities of the system. (pp. 351,352)

Researchers who have analyzed the state-of-the-art computer have concluded that computers are not capable of understanding such abstract concepts as aesthetics and philosophy, but can only process quantifiable information. Therefore, a design problem must be stated in terms of quantifiable information prior to being applicable to CAAD systems (Haviland, 1969; "High Technology," 1982, Mouse, 1973; Kennedy, 1973; Pato, 1980). Furthermore, a CAAD system that effectively meets the needs of the architect should address the architectural design process by the application of an architectural design theory (Eastman, 1972a, Reynolds, 1971).

Reynolds (1971) discussed, in general, theory construction which could be used in the formulation of a theory of

architectural design to help in the development of CAAD systems. First, architects must agree on defining certain terminology that can be universally accepted for developing statements about the architectural design process. Secondly, architects should "be as explicit as possible in defining new concepts" (p. 16).

To overcome the problems related to the disagreement among architects that may occur in combining the various sets of statements which will develop a variety of predictions and explanations about the process, Reynolds (1971) offered the following:

> The solution of this problem is to have a logical system, independent of the substantive content, that can be used to specify the relation expressed in a single statement as well as the implications of combinations of statements. There should be shared agreement about the predictions made within this logical system independent of the content of the theory. In other words, the logical system could be used with different theories treating different phenomena. (p. 16)

Pate (1980) concluded his research by emphasizing the need for a unified definition of the architectural design process. Furthermore, "a general theory of architectural design should be formulated that could be universally applied to various types of architectural design problems" (p. 169). Achieving a unified definition of the architectural design process should give insight into an effective utilization of computers within this process. This in turn should enable computer personnel to develop the appropriate CAAD system for designers.

Computer-Aided Architectural Design (CAAD) Systems: Available and Actual Use in Architectural Education and Professional Practice

Bates (1984) studied the available computer technologies and defined three basic types: (a) decision support systems, (b) computer-aided design (CAD), and (c) management information systems. He found that the CAD systems are most commonly applied to the following graphics tasks:

1. Documentation of existing facilities--tracing or redrawing of as-built drawings and overlays, . . .
2. Area measurements--calculation of spaces occupied by tenants or different activities within the facility.
3. Planning and designing--drafting changes to existing layouts and developing the drawings for new ones.
4. Graphics inventories--keeping track of people, space, and equipment with annotated drawings. . .
5. Visualizations--dynamic, three-dimensional displays used in lieu of physical models, isometric drawings, and renderings. (p. 7)

However, Bates found that these products are oriented towards mechanical design, microelectronic circuit design, or general purpose drafting. He found that "architectural and facilities applications have been a low priority with most vendors" (p. 8).

Three surveys were conducted in the period 1981-1982 for the purpose of determining which computer activities were being carried out in architectural education and professional practice. The first, conducted by the Royal Institute of British Architects (RIBA), surveyed the use of computers in architectural practice in the United Kingdom. The survey was sent to 2,500 practitioners; 804 were completed and returned. The results of the survey showed

that the majority of "programs are devoted to practice management within the following three categories: general accounting, job costing, and general word processing . . . [that is,] a large proportion devoted their computing resources to the more routine functions of accounting and costing" (Stevens, 1981, p. 82).

The second study was conducted by Architectural Record for practitioners in the United States ("The Results," 1985). This survey was addressed to architectural firms. Of those using computers 278 responded, of the non-users 148 answered.

The non-users commented that they did not have computers because they were "concerned about rapid change in computer capabilities, and systems seem outdated before you can learn to use them" (p. 37). Furthermore, they said there was a "fear of computers by principals or management reluctant to change from the old ways" (p. 37).

The computerized firms responded that they used the machines in office management, project cost analysis and control, project scheduling, architectural engineering, and graphics functions. However, they stated that the most benefits they gained from computers were, in the order mentioned, better specifications writing, office management efficiency, accomplishing better job cost estimates, budget and cost analyses, increase in working drawings productivity, and simplification of the task of preparing proposals and contracts. A relatively low percentage mentioned that more design alternatives can be studied in a given time period (pp. 38,41).

The third survey was conducted in 1988 by the Association for Computer-Aided Design in Architecture (ACADIA). A questionnaire was distributed to the 101 architectural schools which were members of the Association of Collegiate Schools of Architecture (ACSA); 88 schools responded. The survey indicated that the computer curriculum in these schools was generally related to applications in technology, structures, and graphics. Only 13 schools indicated some interest and reported research in the area of computer utilization in the architectural design process ("CAAD Activities," 1989).

Cautions and Fears About Computer Use in Architecture

The last 20 years showed a rapid development in computer technology. As the cost of the machines decreased, many architectural firms introduced the computer within their daily practice in a variety of areas. As in any momentous technological development, two camps of thought were bound to develop (Haviland, 1986). On one hand there are the "machine-firsters: the machine is the answer to all problems, and has the ability to replace the man that created it" (p. 5). On the other hand there are the "man-firsters: the machine is evil, it is not in the tradition of man, and it should not be given the chance to replace him" (p. 5).

The researchers stated that the state-of-the-art computer can only serve as a useful tool in supplementing the architectural design process; it has its limitations (Dixon, 1984; Haviland, 1986, Roberts, 1985; Stoker & Weingarten, 1983, Wendle, 1983).

Wendle (1983) cautioned that blind belief in the computer would result in the limitation of the architect's ability to think and respond creatively. He outlined two main problems confronting computer users:

1. Self-improvement is not automatic. That is, a poorly implemented system will simply record, tabulate, coordinate, and print the wrong information faster, more consistently, and more efficiently than the human replaced by it.
2. Those who are interested in architectural graphics applications are faced with the problem of discerning between precision and accuracy. Computers are incredibly precise while the priority should be accuracy rather than precision.

Haviland (1966) outlined two additional problems which were as follows. The computer, in spite of its ability to uncover new paths, or to lead thought in new directions by listing new combinations, does not produce new ideas. Furthermore, while it can reorganize data along any predetermined format, it looks to human beings for subjective evaluation of that data. Roberts (1965) concluded his research study by stating that

> the computer can do only those things which it is told to do. It cannot create. It is a logical machine, which understands only a few complicated languages. It will calculate, solve mathematical equations, read, write, store, and pull out of storage. But it cannot make choices. (p. 1).

Advances in computer technology, however, have opened up new possibilities. Dixon (1984) and Stoker and Weingarten (1983) argued that graphics programs help the architectural designer

visualize alternatives in the early stages of the design. They emphasized that the designers think and judge and that the computers help. Hayt (1984) interviewed a practicing architect who argued that "it is computers' mastery of knowledge that means more to creativity than efficiency" (p. 35). He stated that the real advantage of computers is in giving a thorough grasp of design. This is achieved by the computer's role in the following:

> First, creative architectural design comes from knowledge about the design problem . . . [that is,] the gathering of all those bits and pieces that constitute the program--from the client's preferences and processes to those elements that are germane to the basic functioning of the building type.
>
> Second, the true quality of the design is limited by the number of alternatives explored. Clearly synthesizing information that has been gathered into a program and showing the alternatives that can be derived is an area in which computers far outstrip human capacities in terms of analyzing alternate building massing, floor plans, etc.
>
> Third, decisions reached in the early phases of a design control its success or failure, meaning that no amount of tinkering with a bad basic decision later can make it right. (p. 35)

Hayt stated that architects need computers because the machines' "efficiency can leave time to think, to produce better results and to use real creative skills" (p. 35). However, he did anticipate this problem: "With the emphasis on technical competence, something only meant to serve design, there may be a lot of potentially talented architects who will simply be turned off" (p. 35). Hayt feared that "people who don't sit down with a pencil and paper to draw don't see things. They are not as perceptive" (p. 35).

Architectural Education and Professional Practice

Integrating new technology into existing practices is an old and difficult problem. It is, perhaps, especially difficult for those who love tradition to reconcile the demands of the new technology with the grace, beauty, and accepted standards of the old, familiar ways. This problem is well documented. Echols and Day (1973), for instance, said:

> Since the introduction of the industrial revolution, the magnitude of the social and physical problems and opportunities has greatly expanded. Changes in methodologies, techniques, and facilities have already occurred; earlier methods became traditional and new and renewed methods are constantly needed to replace the older orders. This process is continuous in the evolution of any search for the requirements and products of the future. (p. 77)

This problem is greatly exacerbated today, because technological changes have accelerated. In the field of architecture there is a growing need for practitioners to employ the latest technology in order to be competitive. Yet, this must be done without losing the unique human contribution--the design of the structure.

This problem extends into the educational system. In the last two decades there has been a growing concern that fewer students of architecture are developing the skills and knowledge to plan and to design buildings and, at the same time, to incorporate the best of modern technology. It has been implied that this is a result of inadequate academic training. The schools have been urged to examine their curricula to meet the needs of students who wish to take their place in architectural offices upon graduation (Greenfield, 1972).

In each era the problem for the educators is to define those abilities which a student should acquire in order to become an architect in the professional sense. In an early book now regarded as farsighted, Scope of Total Architecture, by Walter Gropius (1955), architectural education goals, tasks, and means were broadly stated. Gropius described what he perceived to be the important ability of a young architect, namely to be able to find his/her way in whatever circumstances. "I want him independent to create true, genuine forms out of the technical, economic, and social conditions in which he finds himself, instead of imposing a learned formula onto surroundings which may call for an entirely different solution" (p. 17). "What I do want is to make young people realize how inexhaustible the means of creation are if they make use of the innumerable modern products of our age, and to encourage these young people in finding their solutions . . ." (p. 3).

However, the relationship between architectural education and professional practice was not settled by these statements. Currently, one of the most important and interesting aspects of the debate over this complex relationship concerns the gap between the education of the student and what the marketplace demands. In 1985 the debate was summed up by Filson:

> [On one hand], that architectural education should infuse the necessary professional, practical, and technical skills and abilities in students for them to productively join architectural practice at entry level positions. . . . Or, on the other hand, that architectural education should be a truly liberal education in the traditional sense--and that "education for education's sake," while addressing professional issues, is the most productive preparation of young professionals in the long run. (p. 58)

Copeland, in 1984, described how the architectural schools attempt to resolve the dual needs within the limits of the curricula:

> Architectural education should provide a balance between training--that is the imparting of necessary skills--and the acquisition of knowledge, that component enabling the student to make proper use of the skills that she or he has acquired. . . . Therefore in describing the scope of work within the school, two types of instruction are offered, professional and general; the first providing vocational training combined with the essentials of a liberal education, and the second giving a liberal education in which history and appreciation of art and its technical expression in drawing and design form the major interest. (p. 45)

Copeland proposed that architectural educators conceptualize the curricula and that educational programs should be organized around three areas: (a) knowledge, (b) training, and (c) practice. Today, to effectively incorporate the last area into the curriculum, educators have to look at what the profession needs. One aspect of modern practice that is becoming more and more important is the use of computers.

McShaffrey (1985) wrote that there should be a very close integration of computer skills with construction practices in architectural education. He commented that when the technological aspects of architecture are separated from the whole creative process, then there is a disservice to the education of students. He emphasized that computers will be prominent in the future of architecture:

> The immediate future may also provide an even greater opportunity for cooperation between professional offices and schools. Barriers between practice and theory can be broken down even further, and professional development through a continual education process may become the

> norm rather than the exception. . . . There must be a clear commitment to research and research methods if education is to offer leadership to the profession and industry rather than vice versa. . . . Our students need to have secure footing, so that they are not afraid to address change as a natural and evolutionary process. The advent of the microcomputer and the widening scope of professional services are elements that will assist us in enhancing that educational process. (pp. 55,56)

Computer-aided design (CAD) is one area in which the gap between the educational sector and the profession is seen as especially significant. In 1984, Thomas Lazear conducted a survey to examine the current efforts of both educators and those in the industry. He wanted to determine how aware each was of the other's problems in the area of developing CAD-capable personnel. The data were collected through interviews of executives at firms using CAD and educators at universities and vocational schools where CAD was taught.

The responses revealed that some problems in the industrial sector were as follows: Established designers resist the implementation of CAD; the installation of CAD systems is expensive, especially for smaller architectural firms; and there is the need for management awareness of CAD. To help solve the industry's problems it was suggested that educators could help by teaching courses in "managing change" to engineering and architecture students. In addition, the education sector could research low-cost CAD methodology.

The survey revealed that the main problems in the education sector are shortage of qualified instructors, funding, and the development of appropriate resources and course materials. It was

suggested that the role of industry in solving the educational problems would be to provide three aids: a source of funding, some trained part-time instructors from the industry, and summer employment training for instructors to use their resources.

Considering that there is a gap between architectural education and professional practice, the question arises as to what should be done. To reduce this gap, Filson (1985) proposed a post-first-professional-degree which involves clinical educational programs leading to certification to achieve early competence in practice. "A number of clinical education centers similar to 'teaching hospitals' could be established around the country at schools interested in such activities, with a three-year curriculum involved especially in professional development" (p. 32).

The Filson proposal is one method in the effort to reduce the gap between architectural education and practice. The goal, to bring the two sectors together, is a theme in the literature surveyed. In 1954, for instance, Bannister said:

> The schools have plenty of scope to pursue their necessary and legitimate objectives. They will do well to maintain the closest liaison with the profession in order to adjust content and method to the changing needs of practice. And, by the same token, the profession, too, must apply its highest wisdom, most sympathetic understanding, and most penetrating vision to the problems of education. (p. 109)

The Nominal Group Technique (NGT)

The Nominal Group Technique (NGT), developed by Andre L. Delbecq and Andrew H. Van de Ven in 1968, is used to enhance the

generation, exploration, and communication of ideas relevant to problem-solving situations (Mortensen & Holmes, 1983). It was developed based on social-psychological studies of decision conferences, management science studies of aggregating group judgments, and social work studies of problems surrounding participation in program planning (Delbecq, Van de Ven, & Gustafson, 1975). Since it was developed, the NGT has gained extensive recognition and has been widely applied in health, social service, education, industry, and government organizations.

The NGT is used to identify and collect information in a small group setting. It is a special-purpose group process appropriate for identifying elements of a problem situation, identifying elements of a solution program, and establishing priorities (Scott & Dedrick, 1982). "It is a process that provides a structured setting for obtaining qualitative information from groups who are familiar with a situation or a problem area" (Price, 1985, p. 3). Unlike most interacting group techniques, where interaction among members takes place with very little structure, the NGT requires individuals to work with the presence of others but does not allow verbal interaction except at specific times (Ford & Nemiroff, 1975; Mortensen & Holmes, 1983).

The NGT panel should consist of 5 to 10 members (Delbecq, Van de Ven, & Gustafson, 1975; Ford & Nemiroff, 1975; Gepson, Martinko, & Belina, 1981; Newell, 1978). Research focused on decision making shows that "a group made up of less than five members lacks resources in terms of the number of critical judgments available to analyze the problem and arrive at a

decision. On the other hand, adding beyond 10 members often does not increase group accuracy" (Delbecq, Van de Ven, & Gustafson, 1975, pp. 69,70).

The NGT process normally consists of six steps, with the possibility of three additional steps if they are needed: (a) introduction to meeting, (b) silent generation of ideas in writing, (c) round-robin listing of ideas, (d) discussion for items clarification, (e) selection and ranking of items, (f) tabulation of results, (g) discussion of ranked items, (h) selection and second ranking, and (i) tabulation of results. Steps g through i are actually a repeat of steps d through f.

Delbecq, Van de Ven, and Gustafson (1975) identified a number of characteristics for the NGT process which facilitate decision-making performance:

1. Low variability among groups in number and leader behavior leads to consistency in decision making.

2. A balanced concern for social-emotional group maintenance roles and performance of task-instrumental roles offers both social reinforcement and task accomplishment reward to group members.

3. The silent independent generation of ideas, followed by further thought and listing during the round-robin procedure, results in a high quantity of ideas.

4. Search behavior is proactive, characterized by extended periods in generating and clarifying alternative dimensions of the problem, tendencies for high-task centered group effort, and the generation of new social and task-related knowledge.

5. The structured process forces equality of participation among members in generating information on the problem.

6. NGT meetings tend to conclude with a perceived sense of closure, accomplishment, and interest in future phases of problem solving. (pp. 33,34)

However, with these positive characteristics of NGT, Delbecq, Van de Ven, and Gustafson (1975) outlined some difficulties that are frequently encountered in conducting NGT meetings. They include

1. Extended preparation for NGT meetings is necessary to clearly identify the information desired from a group, and to provide the necessary supplies. NGT, therefore, is not a spontaneous group meeting technique.

2. Inflexibility of the structured NGT format makes it difficult to make adjustments or to change topics in the middle of the meeting. NGT is generally limited, therefore, to a single purpose, single-topic meeting.

3. Conforming behavior to a structured format is required on the part of all participants, a condition which is not immediately comfortable to inexperienced participants. (p. 34)

The advantages to the technique clearly outweigh the disadvantages. Experience with this technique has proven its virtues. In addition to the production of a useful end product, NGT encourages equality in participation, and eliminates the domination of vocal participants or those with strong personalities (Delbecq, Van de Ven, & Gustafson, 1975; Mortensen & Nelmes, 1983, Price, 1985, Newell, 1978). Newell (1978) stated that

> the silent recording and round-robin listing also produce a more comprehensive set of ideas than do typical group discussions where one or two ideas often hold the group attention. Finally, not only are arguments avoided, but the structured process allows conflicting ideas to receive the equal attention of the group (p. 39)

In a case study in which the NGT was used in the process of structuring a curriculum development team's preliminary course

planning, O'Neil and Jackson (1983) stated the benefits of the technique in terms of task-instrumental activity and of socio-emotional processes as follows:

i. Task-instrumental advantages:

(1) The tendency of interacting groups to focus on themes for lengthy periods is circumvented.

(2) Hidden agendas are made public early in the group's life.

(3) Convergence on a decision, without available information, is postponed.

(4) The volume of ideas generated in a given time is greater.

(5) Hitch-hiking on the ideas of others is encouraged.

ii Socio-emotional advantages.

(1) All participants are allowed an equal opportunity for contributing to the joint task; the influence of dominant (high status) members is minimized.

(2) Group pressures for conformity are restricted.

(3) Leadership struggles and other personality clashes are avoided.

(4) Focus on task activity is higher in that group-maintenance factors are de-emphasized, task avoidance behavior is low.

(5) Group satisfaction with the process is higher. (p. 132)

Despite constraints associated with the NGT and its application, researchers agreed that it is a respected technique, it is "intended to be used and works best in situations where the end result requires problem identification, solution aspiration, and the setting of priorities where the judgment of several individuals must be brought into a group decision" (Mortensen &

Holmes, 1982, p. 9). Moreover, in the curriculum development field it was strongly recommended that planners should use this simple technique which would allow them to identify rapidly the range of issues central to their course, and which enhances the process of experience exchange prior to problem-solution (Hegarty, 1977).

Summary

The literature reviewed in this chapter revealed three main points:

1. Computers are being introduced rapidly into the architectural profession. There is interest in incorporating computers into the design process. In addition, there is an expressed need for architectural schools to integrate computers effectively within the design education studios.
2. Computer technology is expensive and is under-utilized in the architectural schools. This is resulting in a gap between education and practice.
3. The debate between educators and practitioners on how to effectively utilize computers in the design process is on-going.

Review of the literature points to the usefulness of a study that would try to identify the potential uses of computers within the architectural design process as well as the curriculum needs that would allow the integration of computers within architectural design education studios. The Nominal Group Technique, shown by the literature to be a useful curriculum development tool would be an appropriate way to conduct the needed research.

CHAPTER III
METHODS AND PROCEDURES

General Research Design

This research was carried out in three phases. Phase I was conducted in the form of a Nominal Group Technique (NGT). A group of 10 faculty members from the Department of Architecture, University of Florida, were selected to participate in the NGT panel. Two NGT meetings were held on two separate days to allow participants to respond to the research questions of this study. In the first meeting the panel discussed the potential uses of computers within the architectural design process, and in the second meeting, the panel discussed the curriculum needs that would allow the integration of computers within architectural design education studies.

In Phase II, the findings of the two NGT meetings were distributed to the architectural schools which were members of the Association of Collegiate Schools of Architecture (ACSA) and to a random sample of architectural firms. A comparison of the educators' perceptions and evaluations of these findings with those of practitioners served as the base for the final recommendations.

In Phase III, the findings of the analyses conducted in Phase II, the NGT process, and the literature review served as the base

for the development of a designer/computer interactive model and an architectural design/computer integrative curriculum proposal.

Subjects

Nominal Group Technique (NGT) Participants

The NGT panel was comprised of 10 faculty members from the Department of Architecture at the University of Florida (see Appendix A). The Dean of the College of Architecture and the head of the Computer Development Committee nominated the panel based on two criteria: involvement in teaching architectural design and knowledge and/or research activities related to computer-aided design.

Architectural Schools and Firms Sample

Two groups of subjects participated in the third phase of the study. Subjects invited for the first group were architectural educators. Subjects invited for the second group were architectural practitioners. The architectural educators selected were faculty members of those 122 schools listed in the 1986-87 directory of the Association of Collegiate Schools of Architecture (ACSA). The architectural practitioners were associated with firms selected from the 1986 directory of registered firms in the southeast and northeast regions.

The selection of the original list of firms was based on the following criteria: the firm size (five or more members), type of work (at least 75% architectural design projects), and location

(located in cities with population of 75,000 or more). A random sample of 158 architectural firms was selected from the original list.

The architectural schools were organized into two subsets as follows: architectural schools currently involved in computer-related research activities and having experience in specific computer applications within the architectural design process (computerized setting), and architectural schools not involved in computer-related research activities and applications (non-computerized setting) according to respondent self-report.

The sample of architectural firms was organized into two similar subset groups using the same criteria as for the educators. Architectural schools and firms were assigned to these subsets to allow for a comparison of the responses of educators with those of practitioners. The comparison was based upon the type of setting in which they worked.

Procedures and Collection of Data

After the development of the two research questions, the Nominal Group Technique (NGT) panel of participants was selected with the assistance of the Dean of the College of Architecture, University of Florida, and the head of the Computer Development Committee in the college. This researcher met with the selected NGT participants individually, indicating the unique qualifications which had been ascribed to them, reviewing the process of the two NGT meetings, stressing the meeting's objectives, outlining the requirements for participation, and

providing the needed clarifications for the research questions and the nature of the NGT process. Due to the nature of the NGT process, it was decided that a faculty member would act as the group facilitator (leader) of the two meetings.

The Nominal Group Technique Meeting (NGT)--First Day

The first NGT meeting involved the nine steps as outlined by the technique's developers (Delbecq, Van de Ven, & Gustafson, 1975) as follows:

1. Introduction to meeting: During this step the group facilitator welcomed each participant, discussed the purpose as well as the importance of the meeting, and pointed to the importance of each group member's contribution. This step was needed because when individuals come together to participate in a group setting, perceptions of why the group was formed will affect performance (Delbecq, Van de Ven, & Gustafson, 1975).
2. Silent generation of ideas: In the second step of the NGT process each participant was given a worksheet with the research question at the top--"What are the potential uses of computers within the architectural design process?" After reading the research question to the group, the facilitator asked each participant to write silently and independently as many ideas as could be thought of in response to this question. These responses were required to be made in short phrases or in a few words. A period of approximately five minutes was allowed for this step.

3. Round-robin listing. After completion of the individual assignment as described in step two, the group facilitator asked the participants to share their ideas with the entire group. Each group member, in turn, presented one idea at a time which was recorded verbatim by the facilitator on a flip-chart. This process continued without discussion, until all ideas were recorded. At the same time the group facilitator encouraged the generation of additional new ideas based on the ones presented by the others in the group. The product of this step was a list of 36 potential uses of computers within the architectural design process (see Appendix E).
4. Discussion for clarification. After all of the ideas were listed on the flip-chart, the facilitator led a group discussion on the recorded ideas for the purpose of elaboration and clarification. The purposes of this step were to make sure that each participant fully understood the meaning of each idea listed and to allow presentation of different opinions without undue arguments.
5. Ranking of ideas: This step of the NGT process enabled participants to arrive at a preliminary group consensus prioritizing each idea on the total list according to its perceived importance. Each participant, without interacting with others, was asked to select the nine most important ideas (potential uses of computers) from the total list and write them on separate 3"x5" index cards. Next they were asked to rank them in order of priority. After the ranking

values were assigned to each idea (9 high-1 low). The cards were collected by the group facilitator and were shuffled.

6. Tabulation of results: After shuffling all the cards together, to assure anonymity, the facilitator asked a group member to dictate the idea listed on each card and its ranking and recorded it on the flip-chart. A preliminary group decision was made regarding the importance and priority of each idea by obtaining a sum value score of each idea.

7. Discussion of ranked ideas: After the tabulation of the ranking, the facilitator led a group discussion of the preliminary vote examining the inconsistencies in the voting patterns. There was rediscussion of ideas which were judged as receiving too many or too few votes.

8. Final Vote: After the discussion of the ranked ideas, the participants were given a final voting form (see Appendix F) where they were again asked to select the nine most important ideas from the total list on the flip-chart, list them in ranked order of importance, and rate each idea in terms of its potential on a 0-10 scale where 10 indicated high potential and 0 indicated low potential.

9. Tabulation of final results: After completion of the voting process, the group facilitator recorded the results on the flip-chart as in step six of the process. A group decision was made regarding the importance and the priority of each idea concerning the potential use of computers within the architectural design process by obtaining a value score of the sum of ranks multiplied by the number of times the idea

was ranked. The ideas that were assigned values by the participants became items listed on the data sheets (see Appendix D).

The Nominal Group Technique Meeting (NGT)--Second Day

Eight participants were able to attend the second NGT meeting which involved the first six steps of the nine steps undertaken in the first NGT meeting. The last three steps were eliminated because fewer ideas were generated in answering the second research question--"What are the curriculum needs that would allow the integration of computers within architectural design education studios?" Furthermore, there was less diversity in the ranking of the ideas among the participants. The process of the second NGT meeting followed steps one through five and step nine of the first NGT meeting.

The product of this meeting was a list of 13 ideas related to the curriculum needs (changes) that would allow the integration of computers within design education studios (see Appendix C). From these 18 ideas, the participants were asked to select the 7 most important ideas and rank them in order. This was similar to step nine in the first NGT meeting. A group decision was made regarding the importance and priority of each idea by obtaining a value score of the sum of ranks multiplied by the number of times the idea was ranked (see Appendix E) using a similar final voting form as in the first meeting of the NGT (see Appendix G).

After the completion of the two NGT meetings, the list of ideas was analyzed and summarized. Two questionnaires were

developed, one for architectural schools and the other for architectural firms. The questionnaires summarized these ideas and sought the evaluation of them from both architectural educators and practitioners. With the assistance of the Dean and faculty members of the College of Architecture at the University of Florida, this researcher tested the format of the two instruments and made the required changes based on their feedback.

After the formulation of the final copy of the two questionnaires (see Appendices I & K), one questionnaire was mailed to the 100 architectural schools which were members of the Association of Collegiate Schools of Architecture and a second questionnaire was mailed to a randomly selected sample of 150 architectural firms. A letter was attached to the questionnaires from the Dean of the College of Architecture, reviewing the process, the significance of the study, and asking the cooperation of the schools and firms (see Appendices H & J). The questionnaires were followed by telephone calls three weeks later.

The total number of respondents from the architectural schools was 47 (47% of the schools' sample), while the total number of respondents from the architectural firms was 58 (38.7% of the firms' sample).

Instrumentation

The two questionnaires developed were designed to seek the perceptions of the architectural educators (schools) and practitioners (firms) of the ideas generated in the Nominal Group Technique (NGT) meetings.

The questionnaire designed for the architectural schools was divided into three sections (see Appendix I). The first section asked for general information regarding the availability of computers, computer-aided design courses offered, and the areas of application for computers in the school. The aim of this section was to identify the type of setting of the school, that is, whether it was computerized or not.

In the second section of the questionnaire, 23 ideas from the 38 ideas generated in the first NGT meeting were listed. The summary of the list of ideas was derived from the original list after eliminating ideas not directly related to the theoretical design process, such as the potential use of computers in the development of construction documents, and combining overlapping and similar ideas. These 23 ideas were placed as items on the questionnaire.

Opposite each item (design function) listed in the second section, two columns were provided. In column A, respondents were asked to check whether they were using computers in the specific design function under consideration. The aim of this column was to determine whether the rating checked by the respondent for the potential use of computers within this function was based on experience or perception. In column B, the respondents were asked to check the potential use of computers within the design function listed on a 0-4 rating scale. Space was provided at the end of the second section for the respondents to add any additional design functions (ideas) in which computers may have potential.

The third section presented a summary of the curriculum needs (changes) that would allow the integration of computers within architectural design education studios. These needs were generated in the second NGT meeting. Eight items of curriculum needs were eliminated from the original list because they represented self-evident conditions, for example, the presence of a sufficient number of computers and an adequate yearly computer-support budget. The list of the remaining 11 items was divided into three subsections for changes related to (a) curriculum scope, (b) method of teaching, and (c) support staff and activities. Opposite the item of change listed in the third section two columns were provided. In column A, the respondents were asked to check whether or not they implemented the curriculum change under consideration in their schools. The aim of this column was to determine whether or not the schools' perceptions of the change were based on experience. In column B, the respondents were asked to check their perceptions of the curriculum change under consideration on a scale ranging from "strongly disagree" to "strongly agree." Space was provided at the end of the third section for the respondents to add any additional changes not listed.

The questionnaire designed for the architectural firms was divided into two sections (see Appendix K). The first section asked for general information regarding the use of computers in daily practice and the areas of application in the surveyed firms. As in the questionnaire designed for the schools, the aim of this section was to determine whether or not the firm had a computerized setting. The second section was designed exactly as

the second section of the schools' questionnaire to allow a comparison of responses.

Data Analysis

In the first part of the analysis the item rankings for both computer use and curriculum needs, the rating of the computer's potential within each item of use, and the rating of the importance for each item of curriculum need were coded. A value score of overall item priority, for both potential use and curriculum needs, was determined by summing the rank value assigned by participants for each item and then multiplying by the number of times the item was ranked. The formula used is as follows:

$$P = SR \times NR$$

P - the overall item priority
SR - the sum of the ranking values
NR - the number of times the item was ranked

The importance-value for each curriculum need (change) item and the potential-value for each computer use item was derived using the following formula:

$$IP = \frac{SR}{NP}$$

IP - item importance or potential
SR = the sum of the rating values
NP - total number of participants

In the second part of the analysis all data received from the questionnaire responses were coded. With regard to the educators' perception of the curriculum needs (changes) for integrating

computers within architectural design education studios, the data were divided into two groups based on the work setting (computerized and non-computerized). Values were assigned to the four levels of the scale used, where "strongly agree" was assigned the value four and "strongly disagree" was assigned the value one. A one-way analysis of variance (ANOVA) was used to analyze the difference between educators' perception based on their work setting and to test null Hypothesis 1 of this study:

1. There is no significant difference between two categories of architectural educators in their perception of curriculum needs that would allow the integration of computers within architectural design education studios.

In this analysis, the overall educators' perception for the 11 items was the dependent variable and the type of setting was the independent variable with two levels. The data were analyzed within the framework of a general linear model (GLM). The statistical significance of observed mean difference was tested at an alpha level of .05. The one-way ANOVA design can be diagrammed as follows:

(X)	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)
Educators in non-computerized setting	1	3	5	7
Educators in computerized setting	2	4	6	8

To identify where the important difference occurred between the two groups, the researcher conducted a one-way analysis of variance within the framework of a general linear model for each item of curriculum used. The calculated F-ratio was used to identify the greatest difference occurring between the two groups for each item.

With regard to the educators' and practitioners' perception of the potential uses of computers within the architectural design process, the data were divided into four groups within a matrix of two (profession levels) by two (setting levels).

A two-way analysis of variance (ANOVA) was used to test Hypotheses 2, 3, and 4 of this study:

2. There is no significant difference between architectural educators and architectural practitioners in their perception of the potential uses of computers within the architectural design process.

3. There is no significant difference between two categories of architectural educators and practitioners in their perception of the potential uses of computers within the architectural design process.

4. There is no significant interaction between the setting levels and the profession levels categorized in hypothesis three.

In this analysis the overall educators' and practitioners' perception for the 23 items was the dependent variable, the type of setting was the first independent variable with two levels, and the profession was the second independent variable with two levels. The data were analyzed within the framework of a general linear model (GLM). The statistical significance of observed mean difference was tested at an alpha level of .05. The two-way factorial design can be diagrammed as follows:

Profession (X2)	Type of Setting (X1)	
	Users	Non-users
Educators	1	3
Practitioners	2	4

To identify where the important difference occurred among the four groups, the researcher conducted a one-way analysis of variance within the framework of a general linear model for each item of potential use. The calculated F-ratio was used to identify the greatest difference occurring among the four groups for each item.

The findings of the data analysis were integrated into the Five-Step Design Process presented in Snyder and Catenese (1979) to produce the Designer/Computer Interactive Model presented in Chapter V.

CHAPTER IV
PRESENTATION OF THE RESULTS

The purpose of this study was to identify the potential uses of computers within the architectural design process, to identify curriculum needs for integrating computers within architectural design education studies, and to develop a proposal for integrating computers within the architectural design process and curriculum.

The first phase of the study was conducted in the form of the Nominal Group Technique (NGT). Two meetings were held which produced two lists of potential uses of computers and curriculum needs that would allow the integration of computers within architectural studies. In the second phase of this study, a questionnaire was developed in order to obtain architectural educators' and practitioners' perceptions of the NGT findings of the potential uses of computers and the educators' perception of the curriculum needs. Responses to the questionnaire from 47 educators and 58 practitioners were divided for each level of profession into two levels of settings, computerized (users) and non-computerized (non-users). The data were analyzed with a one-way analysis and a two-way analysis of variance (ANOVA).

In the third phase of this study, the results of the NGT process, statistical analyses, and literature review served as the

base for the development of a designer/computer interactive model and an architectural design/computer integrative proposal. This chapter includes a description of the results of the Nominal Group Technique process (Phase I) and the testing of the null hypotheses (Phase II). The description of the interactive model and integrative proposal (Phase III) are presented in Chapter V.

Nominal Group Technique (NGT) Results

The ideas generated from the two NGT meetings with the computed priority, potential of computers, and importance of curriculum needs are presented in Appendices B, C, D, and E. The nine most important potential uses of computers within the architectural design process, ranked according to priority, are presented in Table 2. The seven most important curriculum needs that would allow the integration of computers within architectural design education studies, ranked according to priority, are presented in Table 3. The two lists were derived from the NGT panel group's decision regarding the priority of each item by obtaining a value score of the sum of ranks multiplied by the number of times the item was ranked.

The data in Table 2 show a great disparity in the NGT panel's priority ranking of items between the first two items and the remaining seven. The figures also show that the item, matrix modeling of ideas, was higher in priority ranking than was the item, solid modeling to visualize architectural forms. In spite of the higher ranking for the former use, the panel agreed that computers have more potential in the latter use.

Table 3. Nine Most Important Potential Uses of Computers Generated in NGT #1 Ranked According to Priority

Item	Sum of Ranks x No. Ranked	Priority	Potential
Matrix modeling of ideas (hierarchy & relational)	432	1	8.40
Solid modeling to visualize architectural forms	418	2	5.80
Model physical alternatives 3D (perspective studies)	215	3	4.80
Movement through space	169	4.5	4.50
Site analysis	168	4.5	3.70
Access to research information	162	6	3.90
Transformation studies	106	7	3.80
Sketchpad	108	8	2.80
Comparisons to existing models	80	9	3.30

A similar discrepancy in priorities and potential uses of computers can be noted in rankings 4.5 (tie), 5, and 7 and the last two rankings on the list. While the use of computers in site analysis was ranked 4.5 (tied with movement through space) in the priority list, the panel's voting showed that the potential use of computers within this design function was less than the sixth item on the list, access to research information. The same can be noted for the eighth item, sketches. While it was ranked higher than the item, comparison to existing models, the panel thought that computers have less potential in functioning as sketchpads.

This discrepancy outlined above can be explained by the nature of the instrument (see Appendix F). The priority scale showed the panel's perception of those design functions where the computer's contribution would be most valuable in the overall design process. On the other hand, the potential scale indicated the panel's perception of the computers' contribution within the specific design function.

Table 3 includes a list of the seven most important curriculum needs that would allow the integration of computers within design studies, ranked according to priority. In spite of the variety of needs generated in the NGT meeting which were grouped in three main categories (curriculum scope, method of teaching, and support staff and activities), it is worth noting that all seven of the items to which the NGT panel gave highest priority and importance fell in the category of support staff and activities. The panel perceived that unless these conditions are met--adequate support budget, appropriate software and hardware,

Table 3. Seven Most Important Curriculum Needs Generated in NGT #2 Ranked According to Priority

Item	Sum of Ranks x No. Ranked	Priority	Importance
Provide lots of micro-workstations	308	1	8.12
Time to train students and faculty	272	2	7.75
Adequate yearly computer support budget	136	3	6.98
Hire computer-aided support staff (technicians)	120	4	5.88
More computer development time	90	5	4.50
Provide faculty with appropriate hard/software	80	6.5	4.12
Hire computer-oriented faculty	80	6.5	3.75

time for faculty and students' training, and time for curriculum planning--computers will not be effectively integrated in the design studios. These conditions were also emphasized by the surveyed architectural schools in the second part of this study.

Statistical Analysis

Four hypotheses were postulated for this study. The hypotheses pertained to no difference among the variables of architectural profession and work setting. In testing the first null hypothesis, the researcher conducted a one-way analysis of variance with the overall score of educators' perception of the curriculum needs on the administered instrument as the dependent variable. The factor analyzed was the type of work setting. The two levels of the type of work setting factor were computerized setting (schools which have already implemented the specific curriculum change), and non-computerized setting (schools which have not implemented the specific curriculum change). The means and standard deviations found in the analysis of the two levels of setting are presented in Table 4.

Table 4 Means and Standard Deviations of Educators' Perception of the Curriculum Needs

Group	Mean	Standard Deviation	N
Computerized	3.85	0.56	28
Non-computerized	2.60	0.88	18

Data were analyzed within the framework of a general linear model in testing null Hypothesis 1.

> Hypothesis 1: There is no significant difference between two categories of architectural educators in their perception of curriculum needs that would allow the integration of computers within architectural design education studies.

Hypothesis 1 was tested using an alpha level of .05. The results of this analysis are presented in Table 5. The analysis yielded a calculated F of 31.84, $p=0.0001$ which was significant for Hypothesis 1. The researcher concluded that at 95% confidence level the null hypothesis was rejected. Thus, there was significant difference between those architectural educators who were working in computerized settings and those architectural educators who were working in non-computerized settings in their perception of the curriculum needs, presented in the surveyed instrument (see Appendix A), that would allow the integration of computers within architectural design education studies. Educators working in computerized settings perceived the curriculum needs presented to be more important than educators working in non-computerized settings.

Table 5. GLM ANOVA Summary Table for Hypothesis 1

Source	df	SS	MS	F	p
Setting	1	3.088	3.888	31.84	.0001

N = 45

To identify where the important difference occurred among the 11 items of curriculum needs presented, the researcher conducted a one-way analysis of variance within the framework of a general linear model for each item. The calculated $\underline{F}$-ratio was used to identify the greatest difference occurring between the two groups for each item. The 11 items of curriculum needs ranked in order according to the calculated $\underline{F}$-ratio are presented in Table 6. The greater the $\underline{F}$-ratio, the greater the difference between the two groups in the specific item. The $\underline{p}$ value from the analysis for each item is presented to provide some indication of the difference. Furthermore, the categorization of each item of the curriculum needs (changes) is provided. This categorization was based on the nature of change, whether the change occurs in the curriculum scope (CS), method of teaching (MT), or support staff and activities (SS).

From Table 6, it can be noted that for all the curriculum needs items the calculated $\underline{F}$-ratio and $\underline{p}$ value indicate that there was a difference between the perception of the two groups except for item number 9: Architectural educators working in computerized settings perceived these changes to be more important for the integration of computers than educators working in non-computerized settings. The perceptions of both groups agreed on the importance of hiring computer-oriented support staff (technicians) to effectively integrate computers within the design studios were similar.

Using the sixth item in the ranking list (item #8) as the median, the list indicates that most important differences between

Table 8. Curriculum Needs Items Ranked According to F-ratio

Item #		Description	Mean Score Comp.	Mean Score Non-comp.	F	p
2	(CS)	introduce courses in computer graphics as prerequisites to design	3.44	2.05	20.45	0.0001
8	(MT)	require students to integrate simultaneously all criteria (structures, thermal, etc.) in the design process	3.72	2.92	16.86	0.0002
11	(SS)	promote computer-related research projects	3.80	3.21	15.81	0.0003
4	(MT)	use the "Analysis-Synthesis" method in teaching design	3.30	2.50	12.12	0.0012
7	(MT)	require students to use computers in the labor-intensive work	3.55	2.40	11.99	0.0012
9[a]	(SS)	hire computer-oriented architectural faculty	3.69	2.81	11.50	0.0014
3	(CS)	supplement introductory courses in architectural drawing with computer literacy and programming courses	3.70	3.10	7.80	0.0074

Table 8--continued

Item #		Description	Mean Score Comp.	Mean Score Non-comp.	F	P
5	(MT)	require students to do more analysis of complex data systems required for architectural projects program development	3.44	2.75	7.10	[illegible]
18	(SS)	hold workshops to train faculty and students on computer hardware, software and applications	3.88	3.22	4.80	0.0338
1	(CS)	integrate the technological courses with computer utilization in the design studio	3.88	3.28	4.42	0.0414
9	(SS)	hire computer-oriented support staff (technicians)	3.56	3.88	3.25	0.0786 (nd)

Note: The median F-ratio
(CS) - curriculum scope
(MT) = method of teaching
(SS) - support staff and activities
(nd) - no difference

the two groups occurred in the items related to the method of teaching. However, the greatest difference was in the need to introduce computer graphics courses as prerequisite to design. While educators working in computerized settings perceived the introduction of computer graphics courses as important, educators in non-computerized settings perceived it as the least important.

In Tables 7 and 8, the curriculum needs items are ranked in order of the perceived importance assigned to them from each group. The tables indicate that both groups perceived the changes in the method of teaching to be the least important in their ranking of items. However, educators working in a computerized settings considered changes in method of teaching to be important and needed overall changes, as indicated by their average score, which was greater than 3 for these items. On the other hand, educators working in non-computerized settings considered changes in method of teaching not to be important, as indicated by their score of less than 3 for these items.

Both groups agreed that, to integrate computers effectively, consideration should be given more to changes to support staff and activities than to changes in curriculum scope. Furthermore, the data show that educators working in computerized settings perceived all items to be important with a high mean score of 3.80 and a low mean score of 3.30. Educators working in non-computerized setting perceived the overall items to be less important, with a high mean score of 3.28 and a low mean score of 2.85. In addition, educators working in non-computerized settings perceived more than half the number of items (8 items) to be not

Table 7. Curriculum Needs Items Ranked According to Mean Score of Importance for Educators Working in Computerized Setting

Item #		Description	Mean
1	(CS)	integrate the technological courses with computer utilization in the design studio	3.808
11	(SS)	promote computer-related research projects	3.880
3	(CS)	supplement introductory courses in architectural drawing with computer literacy and programming courses	3.760
6	(MT)	require students to integrate simultaneously all criteria (structure, thermal, etc.) in the design process	3.722
6	(SS)	hire computer-oriented architectural faculty	3.696
8	(SS)	hire computer-oriented support staff (technicians)	3.668
10	(SS)	hold workshops to train faculty and students on computer hardware, software and applications	3.666
7	(MT)	require students to use computers in the labor intensive work	3.556
2	(CS)	introduce courses in computer graphics as prerequisites to design	3.444
5	(MT)	require students to do more analysis of complex data systems required for architectural projects program development	3.444
4	(MT)	use the "Analysis-Synthesis" method in teaching design	3.306

Notes: (CS) = curriculum scope
(MT) = method of teaching
(SS) = support staff and activities

Table 8. Curriculum Needs Items Ranked According to Mean Score of Importance for Educators Working in Non-computerized Setting

Item #		Description	Mean
8	(SS)	hire computer-oriented support staff (technicians)	3.288
1	(CS)	integrate the technological courses with computer utilization in the design studio	3.257
10	(SS)	build workshops to train faculty and students on computer hardware, software and applications	3.222
11	(SS)	promote computer-related research projects	3.214
3	(CS)	supplement introductory courses in architectural drawing with computer literacy and programming courses	3.169
6	(MT)	require students to integrate simultaneously all criteria (structures, thermal, etc.) in the design process	2.825
8	(SS)	hire computer-oriented architectural faculty	2.616
5	(MT)	require students to do more analysis of complex data systems required for architectural projects program development	2.757
4	(MT)	use the "Analysis-Synthesis" method in teaching design	2.500
7	(MT)	require students to use computers in the labor-intensive work	2.405
2	(CS)	introduce courses in computer graphics as prerequisites to design	2.054

Note: (CS) = curriculum scope
(MT) = method of teaching
(SS) = support staff and activities

important, with a mean score less than 3, and disagreed with these proposed changes.

In testing the second, third, and fourth null hypotheses, the researcher conducted a two-way analysis of variance with the overall score of educators' and practitioners' perception of the potential uses of computers on the administered instrument as the dependent variable. The two factors analyzed were the type of profession and the type of work setting. The two levels of the type of profession factor were architectural educators and architectural practitioners. The two levels of the type of work setting factor were users (computerized setting) and non-users (non-computerized) setting. The means and standard deviations found in the analysis of the four groups are presented in Table 8.

Table 8. Means and Standard Deviations of Educators' and Practitioners' Perception of the Potential Uses of Computers

Group	Mean	SD	N
Educators/Users	3.74	0.51	88
Practitioners/Users	3.58	0.71	12
Educators/Non-users	3.13	0.80	17
Practitioners/Non-users	2.78	1.02	35

Data were analyzed within the framework of a general linear model in testing the second, third, and fourth null hypotheses.

Hypothesis 2: There is no significant difference between architectural educators and architectural practitioners in their perception of the potential uses of computers within the architectural design process.

Hypothesis 3: There is no significant difference between two categories of architectural educators and practitioners in their perception of the potential uses of computers within the architectural design process.

Hypothesis 4: There is no interaction between the setting levels and the profession levels categorized in hypothesis three.

Hypotheses 2, 3, and 4 were tested using an alpha level of .05. The results of this analysis are presented in Table 10. The analysis yielded a calculated F of 26.37, p = 0.0001 which was significant for Hypothesis 2; F of 100.25, p =0.0001 which was significant for Hypothesis 3; and an F of 1.70, p = 0.1850 which was not significant for Hypothesis 4. The researcher concluded that at 95% confidence level Hypotheses 2 and 3 were rejected and Hypothesis 4 was retained.

Table 10. GLM ANOVA Summary Table for Hypotheses 2, 3, and 4

Source	df	SS	F	p
Profession	1	2.60	20.37	0.0001
Setting	1	9.43	108.25	0.0001
Profession x Setting	1	0.13	1.17	0.1859

N = 83

Thus, for Hypothesis 2, there was a significant difference between architectural educators and architectural practitioners in

their perception of the potential uses of computers within the architectural design process. Architectural educators perceived computers to have more potential within the overall architectural design process than architectural practitioners. For Hypothesis 3, there was a significant difference between those architectural educators and practitioners who were using computers and those architectural educators and practitioners who were not using computers in their perception of the potential uses of computers within the architectural design process. Architectural educators and practitioners who were using computers perceived computers to have more potential in the overall design process than those architectural educators and practitioners who were not using computers. As for Hypothesis 4, there was no significant interaction between the levels of setting and levels of profession categorized in Hypothesis 3.

The overall F-ratios presented in Table 10 show that the greatest difference among the four groups occurred between the setting levels. This indicated that the factor of using or not using computers had the greater impact on both architectural educators' and practitioners' perception of the computer's potential.

To identify where the difference occurred among the four groups for each item, the researcher conducted a two-way analysis of variance for each item of the potential uses of computers within the architectural design process (see Appendix I). The data were analysed within the framework of a general linear model. The 23 items of potential uses of computers in rank order according to

the overall calculated $\underline{F}$ are presented in Table 11. The higher the calculated $\underline{F}$, the greater the difference among the groups. The $\underline{p}$ value for each item was presented to provide some indication of the difference. The categorization of each item of potential use based on the nature of the task is also shown; that is, whether it is a technical (T) or non-technical (NT) process.

It can be noted that differences existed between two or among the four groups for all items except item 12. For item 12, design cost analysis, there was no difference among the four groups. Figures in Table 11 show interactions between the two factors of analysis for items 3 and 13, yet the testing of the overall hypotheses revealed no interaction. The set alpha of .05 means that 5 out of 100 hypotheses would be rejected by chance. Out of the 23 hypotheses, 2 would be rejected by chance. Therefore, the two interactions produced from the analysis of the individual items could be ignored.

Using the twelfth item (item #22) on the list as the median, Table 11 indicates that most differences among the four groups occurred in the non-technical (NT) items. Educators and users perceived computers to have higher potential in the non-technical items than did practitioners and non-users. The overall calculated $\underline{F}$ presented in Table 10 and the ranking of items in Table 11 suggest that the difference is explained mainly by the type of work setting (20 items) rather than by the profession.

The 23 items of potential uses of computers ranked in order according to the perceived potential given to them by all participants are presented in Table 12. The table shows that the

Table 11. Potential Uses Items Ranked According to overall F-ratio

Item #	Description	Mean Score EU/PU		Mean Score ENU/PNU		Overall F	p
7	(T) shade & shadows studies	3.81	3.41	3.75	2.84	14.98	(P)0.0001 (S)0.0350 (I)0.0938
4	(NT) modelling to visualize interior design	3.87	3.08	3.48	2.60	14.59	(P)0.0001 (S)0.8533 (nd) (I)0.8204
2	(NT) model physical alternatives, 3D	3.98	3.73	3.77	3.11	13.77	(P)0.0022 (S)0.0058 (I)0.1344
3	(NT) solid modeling to visualize architectural forms (exterior)	3.72	3.83	3.72	2.87	8.98	(P)0.0078 (S)0.0280 (I)0.0310a
8	(NT) color studies	3.78	3.28	3.08	2.38	8.40	(P)0.0185 (S)0.0060 (I)0.0072
1	(NT) model physical alternatives, 2D	3.88	3.88	3.58	3.14	8.08	(P)0.1732 (nd) (S)0.0001 (I)0.2048

Table 11--continued

Item #	Description	Mean Score EU/PU		Mean Score ENU/PNU		Overall F	P
13	(T) structural & energy anlysis	3.87	3.70	3.60	3.88	6.37	(P)0.0135 (S)0.0187 (i)0.0472a
23	(NT) evaluate final design solution	3.88	3.41	2.88	2.50	7.71	(P)0.1511 (nd) (S)0.0001 (i)0.5212
8	(NT) movement through space (interior & exterior)	3.78	3.28	3.25	2.73	7.04	(P)0.0195 (S)0.0127 (i)0.9273
5	(NT) sketch pad (to use as a pencil and pad to record ideas)	3.31	3.42	2.77	2.10	7.50	(P)0.3378 (nd) (S)0.0007 (i)0.1802
18	(T) comparison to existing models	3.71	3.26	2.83	2.30	6.93	(P)0.1392 (nd) (S)0.0055 (i)0.0780
02 [b]	(NT) examine preliminary design alternatives	3.53	3.46	3.78	2.85	5.32	(P)0.8520 (nd) (S)0.0082 (i)0.5807

Table II--continued

Item #		Description	Mean Score EU/PU		Mean Score ENU/PNU		Overall F	p
20	(T)	data bank of conceptual design details	3.84	3.65	3.07	3.00	5.11	(P)0.7347 (nd) (S)0.0003 (I)0.4008
11	(T)	overlay investigation (to overlay different plans)	3.62	3.95	3.14	3.45	5.08	(P)0.1765 (nd) (S)0.0005 (I)0.5862
19	(NT)	matrix modeling of ideas and concepts	3.78	3.50	2.88	2.66	4.72	(P)0.4685 (nd) (S)0.0008 (I)0.9828
15	(T)	access to research information program development and decision making	3.46	3.40	3.20	2.74	4.04	(P)0.0718 (S)0.0240 (I)0.5286
16	(T)	site analysis	3.63	3.46	3.27	2.63	4.46	(P)0.0442 (S)0.0365 (I)0.4180
5	(T)	interior space design (furniture/equipment)	3.66	3.65	3.24	3.21	3.08	(P)0.4564 (nd) (S)0.0015 (I)0.5724

Table 11--continued

Item #		Description	Mean Score EU/PU		ENU/PNU		Overall F	p
17	(T)	site inventory of landscape elements	3.78	3.50	2.88	2.74	3.82	(P)0.5054 (nd) (S)0.0027 (I)0.9875
21	(NT)	respond simultaneously to quantitative and qualitative program requirements	3.71	3.08	2.81	2.54	3.38	(P)0.0852 (S)0.0187 (I)0.4296
14	(NT)	grid order control	3.28	3.75	2.83	2.88	3.14	(P)0.3136 (nd) (S)0.0118 (I)0.4180
18	(T)	data base visual presentation (architectural presentation methods)	3.75	3.33	3.07	2.87	2.65	(P)0.2271 (nd) (S)0.0155 (I)0.4424
12	(T)	design cost analysis	3.50	3.50	3.34	3.88	1.83	(P)0.5034 (nd) (S)0.1564 (nd) (I)0.5834

Note: [a] item where interaction occurred [b] The median F-ratio (nd) = no difference
EU = educators/users PU = practitioners/users ENU = educators/non-users
PNU = practitioners/non-users (P) - profession (S) - setting
(I) = profession x setting

Table 12. Potential Uses items Ranked According to Overall Mean Score for all Subjects

Item #		Description	Mean
1	(NT)	model physical alternatives, 2D	3.58
2	(NT)	model physical alternatives, 3D	3.55
11	(T)	overlay investigation	3.53
13	(T)	structural & energy analysis	3.48
5	(T)	interior space design (furniture/equipment)	3.43
3	(NT)	solid modeling to visualize architectural forms (exterior)	3.33
7	(T)	shade & shadows studies	3.33
20	(T)	data bank of conceptual design details	3.30
12	(T)	design cost analysis	3.24
16	(T)	site analysis	3.20
18 [a]	(T)	data base visual presentation	3.14
15	(T)	access to research information for program development and decision making	3.08
8	(NT)	movement through space	3.08
23	(NT)	examine preliminary design alternatives	3.08
4 [b]	(NT)	modeling to visualize interior design	3.03
14	(NT)	grid/order control	3.00
17	(T)	site inventory of landscape elements	2.93
10	(NT)	matrix modeling of ideas and concepts	2.87
6	(NT)	color studies	2.83

Table 12--continued

Item #	Description	Mean
23 (NT)	evaluate final design solution	2.81
10 (T)	comparison to existing models	2.75
21 (NT)	respond simultaneously to quantitative and qualitative program requirements in the design process	2.75
9 (NT)	sketch pad (to use as a pencil and pad to record ideas	2.61

Note: [a] The median item

[b] Discriminator between items with potential and those with less potential

(NT) = non-technical tasks

(T) = technical tasks

items with highest perceived potential dealt with the ability of computers to generate two-dimensional and three-dimensional (2D and 3D) drawings. However, considering item 15 as the median, it can be noted that the participants perceived that computers have more potential in technical (T) tasks and tasks related to the generation of physical alternatives that would help the architect in the decision process. This is also indicated by considering item 14 to be the discriminator between those with potential and those with less potential (mean of 5 or more). The overall perception of the computer's potential was greatest within the technical items.

Summary

Two Nominal Group Technique (NGT) meetings were held, which produced two lists of potential uses of computers and curriculum needs that would allow the integration of computers within architectural design studios. Although the complete lists were used as a base for the instrument, a further refinement of the original lists occurred in the last steps of the NGT process, where participants were asked to identify and rank the most important items in each area (potential uses and curriculum needs). This process produced a list of nine most important potential uses and seven most important curriculum needs (changes). The panel clearly indicated that changes in support staff and activities are absolutely essential for the effective integration of computers within architectural design education studies.

Using the responses to the instrument, which was developed based on the NGT findings, four null hypotheses were tested. Hypothesis 1 posited no significant difference between two categories of architectural educators, based on their type of work setting, in their perception of the curriculum needs that would allow the integration of computers within architectural design education studies. The analysis supported a rejection of Hypothesis 1.

Hypothesis 2 posited no significant difference between architectural educators and architectural practitioners in their perception of the potential uses of computers within the architectural design process. Hypothesis 3 posited no significant difference between two categories of architectural educators and practitioners, based on their work setting, in their perception of the potential uses of computers within the architectural design process. Hypothesis 4 posited no interaction between the setting levels and the profession levels categorized in Hypothesis 3. The hypotheses were tested by a two-way analysis of variance. The analysis supported rejection of Hypotheses 2 and 3 and retention of Hypothesis 4.

Further data analyses were undertaken to identify which specific curriculum needs items and potential uses items had important differences. For the curriculum needs, the analysis showed that both groups of educators perceived the changes in the teaching method to be the least important. Furthermore, they perceived changes related to the support staff and activities to

be the most important in effectively integrating computers in the design education studios.

For the potential uses items, the analysis showed that the greatest difference was explained mainly by the type of work setting variable. The most important difference existed within items related to non-technical tasks, where individuals using computers perceived them to have more potential than did those individuals who were not using computers. Furthermore, the overall perception of each item for all participants showed that computers had high potential in the technical tasks and in generation of physical alternatives that would help the architect in the decision process.

CHAPTER V

APPLICATION OF COMPUTERS TO ARCHITECTURE: AN INTERACTIVE MODEL AND AN INTEGRATIVE PROPOSAL

The results presented in Chapter IV indicated that there were differences between the two levels of the profession factor and between the two levels of the setting factor in the perception of potential uses of computers within the architectural design process. Analysis of the data showed that architects (educators as well as practitioners) perceived computers to have more potential within the technical tasks. Furthermore, the data showed that the most influential factor in accepting computers as useful tools that have potential in the architectural design process was the type of work setting. Those architects who used computers perceived them to have more potential than the non-users.

The purpose of Phase III was to develop a proposal for integrating computers within the architectural design process and curriculum. A model for "designer/computer interaction" within the architectural design process is presented in this chapter. This model was developed based on (a) the Five-step Design Process presented in Snyder and Catanese (1979), (b) the literature review of this study, and (c) conclusions from the data of this research. In addition, a proposal for integrating computers within architectural education programs was developed based on the conclusions from the data in this study.

Designer/Computer Interactive Model

The literature review undertaken for this study and the analysis of architects' perception of the potential uses of computers underscored how the computer is a useful tool for providing the designer with the proper information on which to base design decisions. Computers have high potential in working as information, manipulation, calculation, and display devices (quantitative tasks). Having these tasks performed well will give more time to the designer for creative reasoning and the qualitative tasks associated with the process.

Figure 1 shows the Designer/Computer Interactive Model. The figure illustrates the interaction process between the designer and the computer within the five steps of the architectural design process. As suggested in this model, the roles of both the designer and the computer are conceived in such a way that the potential contribution of each is maximized. That is, the computer is not expected to make qualitative decisions and the designer is freed from time-consuming tasks which the computer is particularly well suited to perform in a more accurate and efficient way. Inasmuch as the qualitative and quantitative aspects of the architectural design process are equally indispensable, the contributions of the designer and the computer are both essential and complementary. These contributions are

1. Initiation: This step involves the recognition and definition of the problem to be solved. In this step both the client and the designer identify the design problem under consideration and state the needs and overall design criteria.

THE DESIGN PROCESS

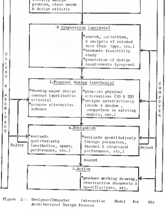

Figure 1 Designer/Computer Interactive Model for the Architectural Design Process

2. Preparation (analysis): This step includes the collection and analysis of information about the problem to be solved. In this step the computer is used to search, collect, and analyze data related to the design project. This includes the gathering and analysis of relevant site and area data (natural and made environment, etc.), financial data (economic feasibility study), and design criteria for specific buildings types. As a final product, computers would provide a written summary of the needs and requirements of the project, and the criteria, along with an extensive analysis that identifies the important issues to be resolved (program).

3. Proposal Making (synthesis): This step includes the generation of ideas and design proposals (alternatives). Both the designer and the computer interact and complement each other. The designer develops the major design concept (qualitative criteria) and proposes alternative schemes as solutions to the design problem. The computer acts as a display device by generating 2D and 3D drawings for these alternatives. In the process the computer would perform the quantitative analysis tasks needed to help the designer in the decision-making process (shade & shadow study, comparisons to existing models, etc.).

4. Evaluation: This step includes the evaluation of the design proposals. The designer evaluates the design qualitatively (aesthetics, performance, etc.) and the computer is used to evaluate the design quantitatively (design parameters,

thermal and structural performance, etc.) Based on both types of evaluation, the designer would accept or reject the proposed scheme. This step is concerned with the evaluation of the overall proposed design according to the program and set criteria. Evaluation is not, however, confined to the last stages of the process; it is an essential and fully integrated element at every step of the process.

5. Action: After the acceptance of the design solution, the computer would generate the needed material for implementing the design (working drawings, construction documents, specifications, legal documents, etc.).

The Designer/Computer Interactive Model indicates that computers cannot design alone. The human role is essential to the process. While the designer contributes knowledge, imagination, and qualitative judgments, the computer contributes processing, manipulation, calculation, and display of information. Furthermore, the computer's contribution would be significant in the simultaneous quantitative evaluation throughout the entire architectural design process.

An Outline Proposal for an Architectural Design/Computer Integrative Curriculum

The data analysis of this study showed how familiarity with computers affects the perception of its potential. The data provided evidence that resistance to computer applications within the architectural design process is directly related to the degree of computer usage. While those who use computers see potential for

the computer to be a useful tool within the architectural design process, non-users see less potential in its application. In spite of the significant differences between the users' and non-users' perceptions, both groups see the application of computers as inevitable in the quantitative tasks of the design process.

Overcoming this resistance involves teaching the appropriate knowledge and skills, so that new graduates of architectural schools can cope with the increased demands of the profession. This could be achieved by the introduction of both required and elective computer literacy and graphics courses within the architectural curriculum. The main objectives would be two-fold: (a) to allow students to become familiar with the computer and its capabilities and (b) to assure that future decisions about computer use by individuals are based on knowledge, not lack of it and/or fear of change. Furthermore, architectural schools should foster the development of the skills that would allow architects to take full advantage of computers within the architectural design process, as proposed in Figure 1. That is, computers should be used as more than efficiency tools for the generation of working drawings in the way that most architectural professional firms use them today.

Figure 2 presents an outline proposal for integrating computers within architectural education programs. The figure outlines general curriculum emphases of a first professional bachelor's degree and a master's degree in architecture including computer-aided design education components.

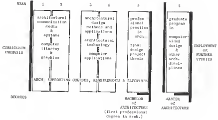

Figure 2. Integrating Computers Within Architectural Education Programs An Outline Proposal.

The proposed program consists of a five-year bachelor's degree and a one-year master's degree. The curriculum of the first two years of the program emphasizes basic architectural communication media (architectural drawing, perspectives, presentation techniques, etc.), architectural systems (structural and environmental control systems, etc.), and required computer courses. These computer courses should emphasize computer literacy (familiarity with the computer and introduction to programming) and computer graphics (generation of graphics with the computer). The objective of these requirements is to make the student familiar with the machine and its capabilities in generating graphics.

The curriculum of the third and fourth years of the program emphasizes architectural design methods and applications, architecture technology, and computer applications. During these years at least one design project with computer applications should be required. The objective of this is to enable individual students, according to their talents and interests, to pursue this approach. Other than that, computer application courses should be optional. In these courses some emphasis should be given to integrating the technological aspects of the entire design process.

The fifth year of the program should allow an overall application of the knowledge obtained in the first years. This could be achieved by assigning a final design project thesis that the student would carry out from inception (initiation step) to completion (action step). In addition, architectural professional

practice courses should be offered. During the final design project, students should be able to fully utilize the appropriate knowledge and experiences with computer applications within the overall design process as carried out in professional practice.

The proposed graduate master's degree program consists of one year in computer-aided design (CAD) and other architectural disciplines. The curriculum of the CAD program should put emphasis on advanced computer programming and application courses.

In summary, the proposed program has the potential to present the computer as a useful tool in the architectural design process. While the core of the proposed program remains the architectural design courses, computer skills are emphasized so that graduate professionals will be able to make informed judgments about the extent of computer use in their work. This proposed program aims at providing the students not only with the knowledge of how to use the available softwares effectively, but also with the capabilities to modify these softwares to meet their needs.

CHAPTER VI

SUMMARY, DISCUSSION AND CONCLUSIONS, AND RECOMMENDATIONS

Summary

Over the last two decades there has been an extensive amount of writing devoted to the use of computers in the architectural design process. The review of the research revealed that most professionals agreed that the use of computers in architectural design is an inevitability. The question is what impact will computers have on the quality of the design process.

This issue, how to utilize computers in design practice in architectural offices, has created a gap in the relationship between practitioners and educators. The literature documented that the majority of architectural practitioners use computers as efficiency tools to increase productivity. This is a reflection of the absence of instruction in the educational sector. This gap created a debate between architectural professionals about the use of computers in architecture. The question of how and where computers could be best utilized to enhance human creativity within the design process has not been answered. The researcher undertook this investigation to answer the question: How can computers, as design aids, be integrated effectively into the architectural design process and design education studios? The

perceptions of educators, practitioners, users, and non-users were investigated.

The purpose of this study was to identify the potential uses of computers within the architectural design process, to identify curriculum needs that would allow the integration of computers within architectural design education studios, and to develop a proposal for integrating computers within the architectural design process and curriculum. The investigation was undertaken within three phases. The first phase was conducted in the form of a Nominal Group Technique (NGT). A group of 19 faculty members from the Department of Architecture, University of Florida, participated in the NGT panel. This panel was selected with the assistance of the Dean of the College of Architecture and the head of the Computer Development Committee. The selection was based on the individuals' involvement in teaching architectural design and their knowledge and/or research activities related to computer-aided design.

Two NGT meetings were conducted. In the initial meeting, the first research question--"What are the potential uses of computers within the architectural design process?"--was discussed. A list of 38 potential uses of computers was generated. In the second NGT meeting, the second research question--"What are the curriculum needs that would allow the integration of computers within architectural design education studios?"--was discussed. A list of 18 curriculum needs was generated.

In the second phase, the investigator developed two questionnaires summarizing the findings of the NGT process. The

questionnaires were designed to seek architectural educators' (schools) and architectural practitioners' (firms) perceptions of these findings. The questionnaires were distributed to a random sample of 150 architectural firms in the eastern region of the United States and 100 architectural schools who were members of the Association of Collegiate Schools of Architecture (ACSA). The responses were used to test the hypotheses of this study. Subjects were assigned to one of four groups: educators/users, educators/non-users, practitioners/users, and practitioners/non-users. The educators' and practitioners' perception served as the dependent variable. The independent variables were the profession factor, with two levels (educators and practitioners), and the work setting factor, with two levels (users and non-users). Statistical analysis procedures included a one-way analysis of variance to test the first null hypothesis and a two-way analysis to test the second, third, and fourth null hypotheses.

Hypothesis 1 posited no significant difference between two categories of architectural educators, based on their work setting, in their perception of the curriculum needs that would allow the integration of computers within architectural design education studios. It was tested by one-way analysis of variance. The analysts supported a rejection of Hypothesis 1 at the .05 level with $F = 31.84$, $p = 0.0001$.

Hypothesis 2 posited no significant difference between architectural educators and architectural practitioners in their perception of the potential uses of computers within the architectural design process. Hypothesis 3 posited no significant

difference between two categories of architectural educators and practitioners, based on their work setting, in their perception of the potential uses of computers within the architectural design process. Hypothesis 4 posited no interaction between the setting levels and profession levels categorized in Hypothesis 3. The hypotheses were tested by a two-way analysis of variance. At the .05 level the analysis supported a rejection of Hypothesis 2 with $\underline{F} = 26.37$, $\underline{p} = 0.0001$; rejection of Hypothesis 3 with $\underline{F} = 108.85$, $\underline{p} = 0.0001$; and retention of Hypothesis 4 with $\underline{F} = 1.70$, $\underline{p} = 0.1959$.

Further data analysis was undertaken to identify the occurrence of the important differences. The analysis results indicated that the important difference between architectural educators' perception of the curriculum needs occurred in the items related to the method of teaching. However, both groups agreed that to integrate computers effectively, consideration should be given first to changes related to the support staff and activities. In addition, the analysis showed that the difference in the perception of the potential uses of computers among the four groups was mainly explained by the type of setting (users and non-users). However, both users and non-users perceived computers to have their highest potential within the technical (quantitative) tasks of the architectural design process.

In the third phase, a designer/computer interactive model and an architectural design/computer integrative curriculum proposal were developed. The model and the proposal were developed based on the results of the study and the literature review.

Discussion and Conclusions

The aim of this research was to determine in which design functions the computer would effectively aid the designer in the design process without jeopardizing the design quality. Determination of these functions reflect both the experience and opinion of architectural educators and practitioners.

After identifying potential uses of computers and curriculum needs, through the Nominal Group Technique (NGT), the researcher tested the four hypotheses postulated for this study. Within the constraints of this investigation, null Hypotheses 1, 2, and 3 were rejected, while Hypothesis 4 was retained.

In relation to the potential uses of computers, the researcher concluded that (a) architectural educators perceived computers to have more potential within the architectural design process than architectural practitioners, (b) architectural educators and practitioners who were using computers perceived them to have more potential within the architectural design process than architectural educators and practitioners who were not using computers, and (c) there was no interaction between the levels of setting and the levels of profession. In other words, as a group, educators have a higher perception than practitioners of the usefulness of computers within the architectural design process. However, users in both groups are more convinced of the computer's potential than are non-users.

Therefore, this study did not substantiate the claim suggested in the literature that architectural schools were well behind architectural practitioners in the area of computer-aided

design. Rather, the research revealed that only the emphasis of educators and practitioners was different. While practitioners were more concerned with immediate practical application, educators were concerned with research and long-range benefits. This may be detrimental to providing the graduates with the needed practical knowledge and skills as required by the profession. Responses to the questionnaire and further analysis of the data indicated that the central issue here was quite simply the familiarity with the computer: Those who were familiar with the computer used it and valued it in varying degrees, while those who were not familiar with it did not value it as highly. Examination of the overall calculated F-ratio revealed that the dichotomy between the educators and practitioners discussed in the literature was not nearly so great or far-reaching in its effect as that between users and non-users. It may be inferred, then, that resistance to the computer as an aid in the architectural design process is fed more by lack of knowledge than by analyzed empirical considerations. This finding underscores the crucial role of architectural schools in exposing their graduates to computers.

A visual examination of the calculated F-ratio for each individual item of potential uses revealed that the greatest difference between educators and practitioners, and between users and non-users occurred in the non-technical (qualitative) tasks. Nevertheless, in spite of the higher rating of the non-technical tasks by the educators and users, an examination of the calculated overall mean score for each item shows that the four groups

perceived computers to have the highest potential in technical (quantitative) tasks and as a generator and display device for 2D/3D alternatives. The researcher concluded from this data that there is agreement among all four groups--educators, practitioners, users, and non-users. At the very least, the computer could be effectively employed in three areas: (a) problem analysis, (b) generation and display of physical alternatives (2D, 3D, etc.), and (c) quantitative evaluation tasks. Given the time-consuming nature of these tasks a consistent interaction between the computer and the designer would be desirable. This will not only allow these tasks to be performed more efficiently and accurately by the computer, but will also free the architect from these routine tasks to devote his/her energies to creative efforts.

In relation to the curriculum needs, the researcher concluded that educators working in computerized settings perceived the curriculum needs presented to be more important to effectively integrate computers within architectural design education studios than did educators working in non-computerized settings.

A visual examination of the calculated F-ratio for each individual curriculum need item revealed that the greatest difference between both groups was in the curriculum needs items related to changes in the method of teaching and the least was in the curriculum needs items related to the support staff and activities. However, an examination of the overall mean score for each item within each group revealed that both groups agreed that changes in support staff and activities are the most important in

order to effectively integrate computers within the design education studios. Furthermore, items related to changes in the method of teaching were perceived to be not important by educators working in non-computerized settings and the least important by educators working in computerized settings.

From this analysis, the researcher concluded that the most important element in integrating the computer within architectural design education studios is the effective utilization of an adequate support staff and activities. In other words, the method of teaching design will not change substantially (with the possible exception of more emphasis on encouraging students to incorporate the computer in their design projects) and, indeed, not even the scope of the curriculum will change appreciably except in the inclusion of computer literacy and graphics courses. What are needed, in the opinion of respondents, are sufficient and appropriate faculty, technical staff, and software and hardware to support workshops and more intensive practice in computer application. The resulting familiarity with the computer, hence the removal of the main deterrent to its use, will generate interest which would feed back into the design studios and would produce a more positive attitude and a wider application of computers within the architectural design process.

Recommendations

Contrary to implications in the literature that educators and practitioners are at odds over integrating computers into the design process, the researcher found that educators and

practitioners are closer together than has been suggested. This convergence of opinion and attitudes as shown in the data analysis points to clearly definable recommendations. The recommendations fall into three broad categories: those dealing with the design process itself, those dealing with the educational background which is the infrastructure of the practicing architect's skills, and those suggesting future studies.

Data analysis showed strongest consensus on the following points: Designers and computers can interact effectively and efficiently in the design process, with computers making especially valuable contributions in technical (quantitative) tasks. In order to utilize the computer's technical capabilities, the researcher recommends integrating the computer in three phases of the design process: (a) problem analysis, (b) generation and display of preliminary design alternatives, and (c) quantitative evaluation.

If the computer is to play a significant role in architectural design, it must be used and its possibilities explored. The three functions mentioned above, as well as any new ones, will be helped by the development of a universal language of architectural design. The researcher recommends, as suggested by others (Reynolds, 1971), that architects themselves develop a unified terminology for these computer functions applicable to the design process. This will contribute to the effective integration of the computer by (a) facilitating the development of software with widespread applicability and (b) improving communications about computer usage among architecture professionals and between

architects and computer program designers. It is hoped that a more precise and widely-used language will produce software based on expressed professional needs rather than on the constraints of computer science.

The data suggest that familiarity with the computer is a key element in its effective use. The more architects know about the computer, the more positive their attitudes are to computer application in the design process and the more possibilities they see for use of the machines. Therefore, it is essential that, in their educational experience, architecture students are exposed to basic computer applications in the design process. Their future decisions, then, to use or not to use the computer in architectural design will be based on their knowledge of the computer's capabilities.

Enriching existing architectural education programs with computer experience requires substantial financial commitment to provide sufficient and appropriate software and hardware. In order to achieve computer literacy among architecture graduates, the following are recommended in the area of support staff and activities:

1. that architecture departments include computer-oriented faculty,
2. that sufficient technicians and support staff be available to maintain software and hardware,
3. that workshops in computer applications be established to train faculty and students or enhance their experience, and
4. that computer-related research projects be promoted.

While no radical changes in the scope of the architectural curriculum are considered necessary, it is essential that existing programs be enriched by requiring introductory courses in computer literacy and computer graphics within the first two years of the program. Elective computer application courses should be offered in the department of architecture for the consumption of interested students.

Early introduction of the computer as a design tool is important. The process of mastering architectural design is, like all learning, progressive. While students are learning the fundamentals of design with traditional tools of paper and pencil, they should also be learning techniques of design using the computer as a tool. The incorporation of the computer as a design tool should begin early in the undergraduate program for at least two reasons: to reduce resistance to a new approach in upper-division studies after students are already "fluent" in traditional techniques, and to ensure that the upper-division is a time of true synthesis and of polishing all skills, and not a time to start over by introducing unfamiliar techniques.

The same can be said for the method of teaching. Even though results of the study indicated that no changes in presentation method were seen to be essential by participants, the researcher recommends that in at least one undergraduate design project computers be fully integrated in the design process. Specifically, the researcher recommends that students use computers to

1. analyze complex data systems needed for the generation of the design requirements (program),

3. generate, analyze, and test quantitatively two-dimensional and three-dimensional models early in the design process,
3. integrate simultaneously all quantitative criteria (structural, thermal, code, etc.) in the design process,
4. evaluate quantitatively the design alternatives, and
5. perform labor-intensive tasks (architectural presentation and details).

Developing a viable program of computer application requires that systematic examination of the curriculum take place. It is essential that departments allocate sufficient curriculum development time for the planning of the recommended computer-related courses. Course development should take into consideration the interests of students and the needs of the profession. These courses should aim at creative computer application, rather than at becoming just one more computer science course. The practical aspects of professional education suggest that both required and elective courses, if developed by and taught in the Department of Architecture, would reap immediate benefits for students because of their direct applicability.

The Nominal Group Technique (NGT) is recommended by the researcher as a highly effective means of achieving these ends by bringing together those individuals most affected by the curriculum. The structured nature of the NGT focuses energies on a clearly defined problem, thus efficiently producing maximum creative output.

In summary, the computer should be seen as a tool which will aid in the design process. While the core of the architectural curriculum should remain the design courses, computer skills should be emphasized in order that professionals be able to make informed judgments about the extent of computer usage in their work. As computer technology progresses, it is likely that functions unforeseen today will be possible. Basic familiarity with the computer will be essential. There is a strong belief on the part of all participants in the research that technical functions of the design can be well served by the computer. But there is an equally strong sense among architectural educators that non-technical functions may be served by the computer as well. This sense should not be disregarded, particularly in view of the upcoming technology of artificial intelligence.

Even without technological advances, professionals who wish to do so should be capable of changing software to meet their needs. At the very least, schools of architecture should offer courses which will enable architectural students to acquire the ability to modify existing software.

A single study in the application of computers to the architectural design process should not be regarded as definitive. However, it is hoped that this study will lead to further research in specific aspects of this topic. The researcher has identified general areas in which the computer might be applied, further studies should be conducted on specific applications to specific proposed design functions. Furthermore, the researcher has made a broad curriculum proposal, further studies leading to the gradual

implementation of the curriculum proposal should be undertaken with immediate feedback and evaluation.

One of the problems associated with the use of computers in the design process is the lack of appropriate software. Studies to pursue the specific application of computers in detail, leading to the development of the needed software should be undertaken as a joint venture between architects and computer science personnel. The architectural profession stands in need of computer software created by design, not by default.

In conclusion, the computer, by performing repetitive and quantitative tasks of the design process, will allow architects now and in the future to devote more time to the creative aspects of design. However, the machines will best serve the profession only when they are utilized by computer-literate architects.

Finally, despite these findings supporting the integration of computers within the design process, professionals should be careful to adapt the machine to the discipline and not vice versa. The creative aspects of design are peculiarly human. The quality of the architectural design process should not be jeopardized in the blind pursuit of technology for its own sake.

APPENDICES

APPENDIX A
NOMINAL GROUP TECHNIQUE PANEL

1. Charles F. Morgan, Group Facilitator
   Associate Professor of Architecture

2. Anthony J. Costa
   Professor of Architecture

3. Martin G. Gunderson
   Associate Professor of Architecture

4. Ronald W. Haase
   Professor of Architecture

5. William C. Henderson
   Visiting Associate Professor of Architecture

6. Orry W. Hill
   Assistant Professor of Architecture

7. Harold W. Kemp
   Professor of Architecture

8. Peter E. Prugh
   Associate Professor of Architecture

9. Gary D. Ridgdill
   Professor of Architecture

10. Tony White
    Associate Professor of Architecture

APPENDIX B
IDEAS GENERATED IN NGT MEETING #1

Item Number	Item Description
1.	Kit of parts
2	Model physical alternatives 2/3D
3.	Design cost analysis
4.	Limited labor-intensive exercises can be accomplished quickly
5.	Respond to qualitative & qualitative program information
6.	Adjacency studies
7.	Structural/E.T. analysis
8.	Matrix modeling (hierarchy and relational)
9.	Examination of preliminary design alternatives
10.	Color studies
11.	Elevational alternatives
12.	Analyze data for patterns or connections
13.	Data bank of design details
14.	Perspectival alternatives
15.	Preliminary energy states
16	Site analysis
17.	Shade and shadow studies

Appendix B--continued

Item Number	Item Description
18.	Solid modeling to visualize architectural form
19.	Program writing tool
20.	Spatial modeling
21.	Model design for specific criteria
22.	Automatic dimensioning system
23	Transformation studies
24.	Sketchpad
25.	Database visual presentation (results & methods)
26.	Development of construction documents
27.	Idea inventory storage
28.	Space planning
29.	Comparisons to existing models
30	Movement through space
31.	Evaluation
32.	Grid/order manipulation
33.	Furniture/equipment inventory
34.	Access to research information
35.	Code check
36.	Overlay investigation
37.	Modeling interior spaces
38.	Inventory of landscape elements

APPENDIX C
IDEAS GENERATED IN NGT MEETING #2

Item Number	Item Description
1.	Require students to test 2D/3D models early in the design process
2.	Integrate technological courses in design studio
3.	Time to train students and faculty
4.	Workshops
5.	Hire computer-oriented faculty
6.	Need to analyze complex data systems better
7.	Hire computer-oriented support staff (technicians)
8.	Provide faculty with appropriate hardware and software
9.	Change course requirements (computer courses)
10.	Security in design studios
11.	Adequate yearly computer support budget
12.	Require students to test design solutions for specific criteria
13.	Introductory courses on computer graphics
14.	Need of large-scale plotter capabilities
15.	Establishing computer network
16.	More curriculum development time

Item Number	Item Description
17.	Establishing computer-related research projects
18.	Provide lots of micro-workstations
19.	Provide optimum design sketching capabilities

APPENDIX D

ITEM RANKING AND PRIORITY CALCULATION FOR NGT #1

Note

Descriptions of the items in Appendix D are found under corresponding numbers in Appendix B.

APPENDIX D
ITEM RANKING AND PRIORITY CALCULATION FOR NGT #1

Item No.	Rank	Times Ranked	Sum of Ranks	No. of Ranks x Sum of Ranks	Priority	Potential Rating	(Sum of Rating/10)
		Priority Calculation				Potential Calculation	
1	—	—	—	—	—	—	—
2	9,9,9,7,9	5	43	215	3	10,10,9,10,10	4.90
3	4,3	2	7	14	17	4,7	1.10
4	—	—	—	—	—	—	—
5	9,7	2	18	32	13	10,8	1.80
6	3,4	2	7	14	16	6,7	1.30
7	9,4,2,4	4	12	48	11	4,7,2,6	1.90
8	8,7,8,8,5,8,9,3	8	54	432	1	10,8,9,7,8,8,9,8	6.40
9	1,8,1,8	4	18	78	18	5,9,8,9	2.90
10	1	1	1	1	21	4	0.40

Appendix D--continued

		Priority Calculation				Potential Calculation	
Item No.	Rank	Times Ranked	Sums of Ranks	No. of Ranks x Sum of Ranks	Priority	Potential Rating	(Sum of Rating/10) Average
11	2,3	2	5	10	18	5,8	1.30
12	9,7	2	16	32	13	10,8	1.80
13	———	——	——	——	——	———	——
14	7,6	2	13	26	14	8,7	1.50
15	———	——	——	——	——	———	——
16	5,3,1,7,6,6	6	28	168	4	7,10,1,7,7,5	3.70
17	———	——	——	——	——	———	——
18	5,6,5,9,8,6,6,6	8	52	416	2	8,7,7,8,10,10,10,8	6.80
19	———	——	——	——	——	———	——
20	7,6,1,9	4	23	92	8	10,8,5,10	3.30
21	6,3	2	9	18	15	6,4	1.20

Appendix D--continued

		Priority Calculation				Potential Calculation	
Item No.	Rank	Times Ranked	Sums of Ranks	No. of Ranks x Sum of Ranks	Priority	Potential Rating	(Sum of Rating/10)
22	—	—	—	—	—	—	—
23	3,6,4,1,3,1	6	18	108	8	6,10,6,5,3,6	3.60
24	4,6,8,7	4	25	100	7	4,7,9,8	2.80
25	—	—	—	—	—	—	—
26	5	1	5	5	20	5	0.50
27	—	—	—	—	—	—	—
28	—	—	—	—	—	—	—
29	4,2,3,3,2,2	6	16	96	5	6,6,3,8,3,7	3.30
30	1,4,8,4,5,6	6	28	168	4	4,8,10,5,10,8	4.50
31	—	—	—	—	—	—	—
32	2,7,4	3	13	39	12	9,5,7	2.10

Appendix D--continued

	Priority Calculation					Potential Calculation	
Item No	Rank	Times Ranked	Sums of Ranks	No. of Ranks x Sum of Ranks	Priority	Potential Rating	(Sum of Rating/10)
33	___	___	___	___	___	___	___
34	8,6,2,3,5,2	6	27	162	8	8,9,1,6,8,6	3.80
35	1	1	1	1	21	3	0.30
36	1,5	2	6	12	17	2,6	0.80
37	___	___	___	___	___	___	___
38	7	1	7	7	19	10	1.00

APPENDIX E

ITEM RANKING AND PRIORITY CALCULATION FOR NGT #2

Note

Descriptions of the items in Appendix E are found under corresponding numbers in Appendix C.

APPENDIX E
ITEM RANKING AND PRIORITY CALCULATION FOR NGT [illegible]

	Priority Calculation					Importance Calculation	
Item No.	Rank	Times Ranked	Sums of Ranks	No. of Ranks x Sum of Ranks	Priority	Importance Rating	(Sum of Rating/8)
1	___	___	___	___	___	___	___
2	1,1,2,4	4	8	32	7	7,8,8,8	3.88
3	1,5,3,4,4,7,4,6	8	34	272	8	9,7,4,9,6,10,7,10	7.75
4	2,2	2	4	8	9	6,6	1.50
5	3,6,5,6	4	20	80	6	6,8,8,8	3.75
6	___	___	___	___	___	___	___
7	4,7,3,5,5	5	24	120	4	7,10,8,9,9	5.88
8	6,7,6,1	4	20	80	6	7,10,10,6	4.12
9	7,4	2	11	22	8	10,8	2.25
10	1	1	1	1	13	5	0.62

Appendix E--continued

	Priority Calculation					Importance Calculation	
Item No.	Rank	Times Ranked	Sums of Ranks	No. of Ranks x Sum of Ranks	Priority	Importance Rating	(Sum of Rating/8)
11	4,5,2,1,6,5	6	23	138	3	10,7,8,6,8,8	5.88
12	3	1	3	3	11	8	1.00
13	3	1	3	3	11	7	0.87
14	2	1	2	2	12	9	1.12
15	3	1	3	3	11	9	1.12
16	6,3,2,5,2	5	18	90	5	8,7,3,10,8	4.50
17	1,2	2	3	6	10	5,6	1.37
18	5,7,4,6,7,3,7,7	8	46	368	1	10,8,7,10,10,10,9,9	9.12
19	1	1	1	1	13	9	1.12

APPENDIX F
RATING FORM FOR NGT MEETING #1 FINAL VOTING

No. from flip-chart	Item Description	Potential Uses of Computers Low … High
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10
____	______________	0 1 2 3 4 5 6 7 8 9 10

Instructions

1. Choose the nine most important items from the flip-chart, and list them in rank-order above.
2. Identify the items by using the number and description from the flip-chart.
3. Rate each item in terms of its potential for computer application on the 0-10 scale, with 0 being low potential and 10 being high potential.

APPENDIX G
RATING FORM FOR NGT MEETING #2 FINAL VOTING

No. from flip-chart	Item Description	Relative Importance (Not Important … Very Important)
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10
____	____________________	0 1 2 3 4 5 6 7 8 9 10

Instructions

1. Choose the seven most important items from the flip-chart, and list them in rank-order above.
2. Identify the items by using the number and description from the flip-chart.
3. Rate each item in terms of its importance on the 0-10 scale, with 0 being unimportant and 10 being very important.

APPENDIX H
ARCHITECTURAL SCHOOLS' QUESTIONNAIRE ACCOMPANYING LETTER

December 30, 1986

Dear Dean

I would like to ask your cooperation with a research project being conducted in the College of Architecture of the University of Florida. Its objectives are to define: 1) potential uses of computers in the architectural design process, and 2) curriculum needs for effectives uses of computers in the design education studies.

The instrument used in the research is the enclosed questionnaire. It should be answered by a person whose perception of the issues closely represents your school's views. Perhaps the Chairman of the Curriculum Committee would be a good choice. If your school is currently involved with computer applications in the design process, we want to know about your experience; if not, we would like to know your viewpoints on future plans for using computers in the design process.

Your response will contribute to a better picture of the uses of computers in architectural education. A similar questionnaire is being sent to architecture firms to survey their current or intended use of computers.

We would greatly appreciate return of the questionnaire in the enclosed self-addressed, stamped envelope before January 16, 1987. As soon as the results of the research are obtained, we will be happy to share them with you

Thank you in advance for your consideration and response.

Sincerely,

Anthony J. Catanese
Dean

APPENDIX I
ARCHITECTURAL SCHOOLS' QUESTIONNAIRE

I. GENERAL INFORMATION

Directions: In this section, please fill in blanks or check all applicable responses.

Name of institution ______________________________

Name of respondent: ____________________ Position: ________

You are Chairman of the department's curriculum committee ____

Member of the curriculum committee ____

Other (please specify) ____________________

1) How many computer and/or computer-aided design courses are offered in the architectural program?

Undergraduate ____ Graduate ____

3) In what areas does the school use computers?

Design courses ___ Technology courses ___ Research ___ None ___

4) Computer terminals are available for the use of:

Faculty _____ Students _____ Others _____ None _____

II. POTENTIAL USES OF COMPUTERS

Directions: In this section, there are statements concerning the potential uses of computers within the architectural design process. Please read each statement, and check in the USING column (A) if you are currently using computers in this activity or not. On the scale provided in column (B), please check the potential use of the computer, based on your experience and/or perception (where 4 indicates high potential and 1 indicates low potential). Space is provided in the end of section II for other potential uses of computers you would like to include.

Appendix I--continued

	(A) USING		(B) POTENTIAL			
	YES	NO	HIGH 4	3	2	LOW 1
1) Model physical alternatives, 2D (plan & elevation)						
2) Model physical alternatives, 3D (perspective studies)						
3) Solid modeling to visualize architectural forms (exterior)						
4) Modeling to visualize interior space						
5) Interior space design (furniture/equipment)						
6) Movement through space (interior & exterior)						
7) Shade & shadows studies						
8) Color studies (color & light effect)						
9) Sketch pad (to use as a pencil and pad for recording ideas)						
10) Comparison to existing models (ability to compare the design to previous arch. work side by side, overlay, numerically)						
11) Overlay investigation (to overlay different plans, e.g. arch. & structural plans for checking)						
12) Design cost analysis (cost as it influence the design)						
13) Structural and energy analysis						
14) Grid/order control (to easily manipulate grid and geometric order through design stages)						

Appendix I--continued

	(A) USING		(B) POTENTIAL			
	YES	NO	HIGH 4	3	2	LOW 1
15) Access to research information for program development and decision making						
16) Site analysis (location, topography, etc.)						
17) Site inventory of landscape elements (design process planning)						
18) Data base visual presentation (using various architectural presentation methods)						
19) Matrix modeling of ideas and concepts (hierarchy and interrelationship)						
20) Data bank of conceptual design details						
21) Respond simultaneously to quantitative and qualitative program requirements in the design process						
22) Examine preliminary design alternatives (function diagrams and sketches)						
23) Evaluate final design solution						
ADDITIONAL USES						

Appendix I--continued

III. CURRICULUM NEEDS

Directions In this section there are statements concerning the curriculum changes that would allow the integration of computers and would take full advantage of them within architectural design education studies. It is assumed that all hard and softwares, as well as supportive facilities are available. The changes are divided into three parts: a) scope of the architectural curriculum, b) method of teaching design, and c) support staff and activities. Please read each statement, and check in the IMPLEMENTED column (A) if your institution has already implemented this change. On the scale provided in column (B), please check the appropriateness of the changes based on your experience and/or perception. Space is provided in the end of section III for other changes you would like to include

(SA=STRONGLY AGREE, A=AGREE, D=DISAGREE, SD=STRONGLY DISAGREE)

	(A) IMPLEMENTED		(B) APPROPRIATE			
	YES	NO	SA	A	D	SD
a) CURRICULUM SCOPE						
1) integrate the technological courses (structures & energy) with computer utilization in the design studio.						
2) introduce courses in computer graphics as prerequisites to design.						
3) supplement introductory courses in architectural drawing with computer literacy and programming courses.						
b) METHOD OF TEACHING						
4) use the "Analysis-Synthesis" method in teaching design where students start with a explicit analysis of the architectural problem before the design stage.						

Appendix I--continued

	(A) IMPLEMENTED		(B) APPROPRIATE			
	YES	NO	SA	A	D	SD
5) require students to do more analysis of complex data systems required for architectural projects program development.						
6) require students to integrate simultaneously all criteria (structural, thermal, code, etc.) in architectural design process.						
7) require students to use computers in the labor-intensive work (arch. presentation & detail work)						
c) SUPPORT STAFF AND ACTIVITIES						
8) hire computer-oriented architectural faculty and/or computer science faculty.						
9) hire computer-oriented support staff (technicians).						
10) establish workshops to train faculty and students on computer hardware, software and applications.						
11) promote computer-related research projects.						
ADDITIONAL NEEDS						

THANK YOU FOR YOUR PARTICIPATION. PLEASE RETURN THE QUESTIONNAIRE IN THE ENCLOSED SELF ADDRESSED ENVELOPE

APPENDIX J
ARCHITECTURAL FIRMS' QUESTIONNAIRE ACCOMPANYING LETTER

December 30, 1986

Dear

I would like to ask your cooperation with a research project being conducted in the College of Architecture of the University of Florida. Its objective is to define the potential uses of computers in the architectural design process.

Enclosed is a questionnaire designed to obtain the perceptions of architects throughout the nation regarding this issue. If your firm is currently using computer-aided design systems, we want to know about your experience; if not, we would like your viewpoint on future plans for using computers in the design process.

Your response will contribute to a better picture of the uses of computers by architects, and will help us better design our curriculum to fit the needs of the profession.

We would greatly appreciate return of the questionnaire in the self-addressed, stamped envelope before January 16, 1987. As soon as the results of the research are obtained, we would be happy to share them with you.

Thank you in advance for your consideration and response.

Sincerely,

Anthony J. Catanese
Dean

APPENDIX K
ARCHITECTURAL FIRMS' QUESTIONNAIRE

I. GENERAL INFORMATION

Directions: In this section, please fill in blanks or check all applicable responses.

Name of firm: ______________________________

Name of respondent: ____________________ Position: ________

1) The firm uses computers in its daily practice:

Yes ______ No ______

* If your answer to question (1) is Yes, please answer question (2) and then proceed to section II. If your answer is No, please go immediately to section II.

2) The firm uses computers in:

Structural & energy analysis ____	Word processing ____
Structural & energy calculations ____	Accounting ____
Design evaluation decisions ____	Color studies ____
Working drawings ____	Schematic design ____
Project control ____	Cost analysis ____

Other (specify) ______________________________

II. POTENTIAL USES OF COMPUTERS

Directions: In this section, there are statements concerning the potential uses of computers within the architectural design process. Please read each statement, and check in the USING column (A) if you are currently using computers in this activity or not. On the scale provided in column (B), please check the potential use of the computer, based on your experience and/or perception (where 4 indicates high potential and 1 indicates low potential). Space is provided in the end of section II for other potential uses of computers you would like to include.

Appendix K--continued

	(A) USING		(B) POTENTIAL			
	YES	NO	HIGH 4	3	2	LOW 1
1) Model physical alternatives, 2D (plan & elevation)						
2) Model physical alternatives, 3D (perspective studies)						
3) Solid modeling to visualize architectural forms (exterior)						
4) Modeling to visualize interior space						
5) Interior space design (furniture/equipment)						
6) Movement through space(interior & exterior)						
7) Shade & shadows studies						
8) Color studies (color & light effect)						
9) Sketch pad (to use as a pencil and pad for recording ideas)						
10) Comparison to existing models (ability to compare the design to previous arch. work--side by side, overlay, numerically)						
11) Overlay investigation (to overlay different plans, e.g. arch. & structural plans for checking)						
12) Design cost analysis (cost as it influence the design)						
13) Structural and energy analysis						
14) Grid/order control (to easily manipulate grid and geometric order through design stages)						

Appendix K--continued

	(A) USING		(B) POTENTIAL HIGH			LOW
	YES	NO	4	3	2	1
15) Access to research information for program development and decision making						
16) Site analysis (location, topography, etc.)						
17) Site inventory of landscape elements (design process planning)						
18) Data base visual presentation (using various architectural presentation methods)						
19) Matrix modeling of ideas and concepts (hierarchy and interrelationship)						
20) Data bank of conceptual design details						
21) Respond simultaneously to quantitative and qualitative program requirements in the design process						
22) Examine preliminary design alternatives (function diagrams and sketchs)						
23) Evaluate final design solution						
ADDITIONAL USES						

THANK YOU FOR YOUR PARTICIPATION. PLEASE RETURN THE QUESTIONNAIRE IN THE ENCLOSED SELF-ADDRESSED ENVELOPE

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BIOGRAPHICAL SKETCH

Mohamed Mohammed Akurawi was born in Cairo, Egypt, on August 20, 1956. He received his high school general diploma from Tripoli High School in June, 1974. He was awarded a scholarship from the Secretary of Education, Tripoli, for undergraduate studies in architecture at Ain Shams University, Cairo, Egypt. He received the Bachelor of Science degree in architectural engineering (5-year professional degree) from the same institution in June, 1980.

He joined the National Oil Corporation, Tripoli, Libya, as an architect in the Oil Housing Bureau from 1980-1982.

In 1982, he was awarded a scholarship for graduate studies in architecture from the Secretary of Education, Tripoli, in the fall of the same year, he started his graduate studies at the University of Florida. After receiving the Master of Architecture degree in summer, 1984, he started his doctoral studies in curriculum and instruction in the same institution.

While pursuing his graduate studies, Mr. Akurawi was awarded a graduate teaching assistantship during the period 1983-1986 and a graduate research assistantship in summer and fall 1986 at the University of Florida, College of Architecture. He is a member of the Association for Computer-Aided Design in Architecture (ACADIA) and Kappa Delta Pi honor society.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James W. Hensel, Chairman
Professor of Educational Leadership

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Gordon D. Lawrence
Professor of Educational Leadership

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Anthony J. Catanese
Professor of Architecture

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Edward E. Crain
Professor of Architecture

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

George Scheffer
Professor of Architecture

This dissertation was submitted to the Graduate Faculty of the College of Education and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August, 1987

David C. Smith
Dean, College of Education

Dean, Graduate School